FIG. 1

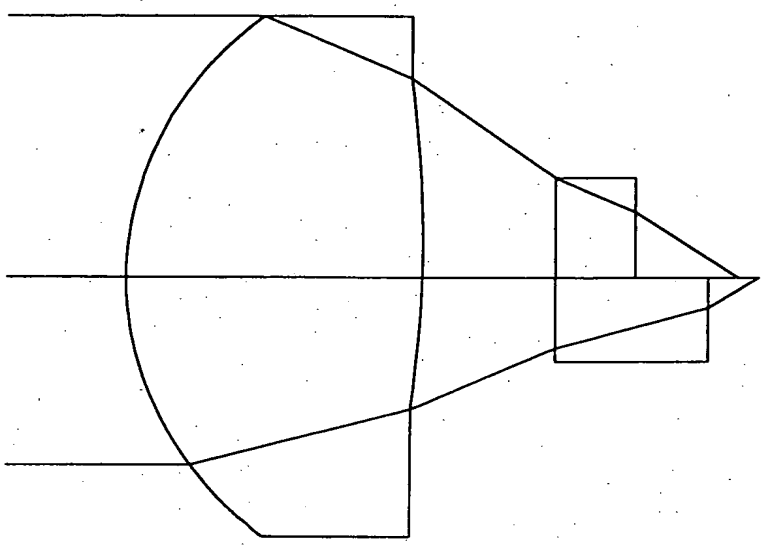


FIG. 2

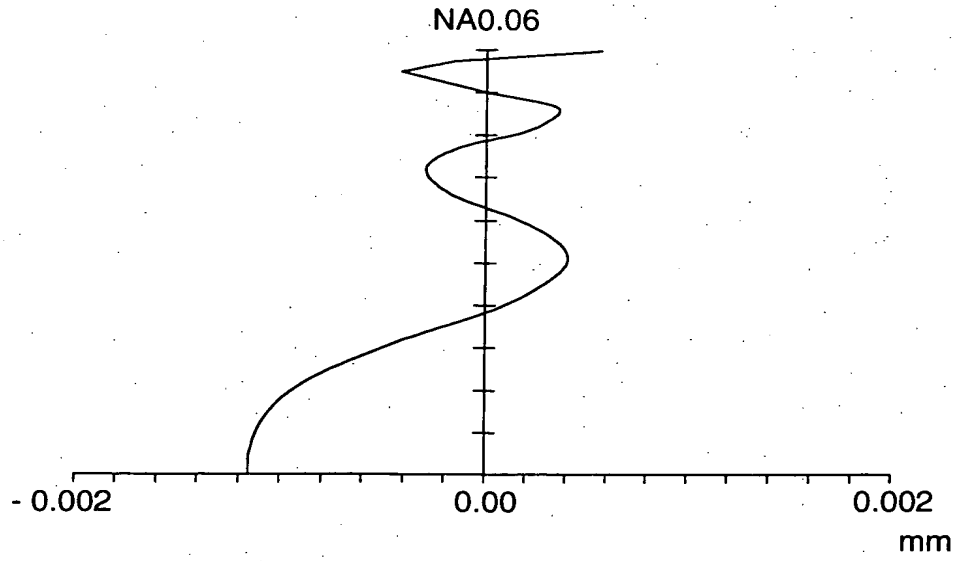


FIG. 3

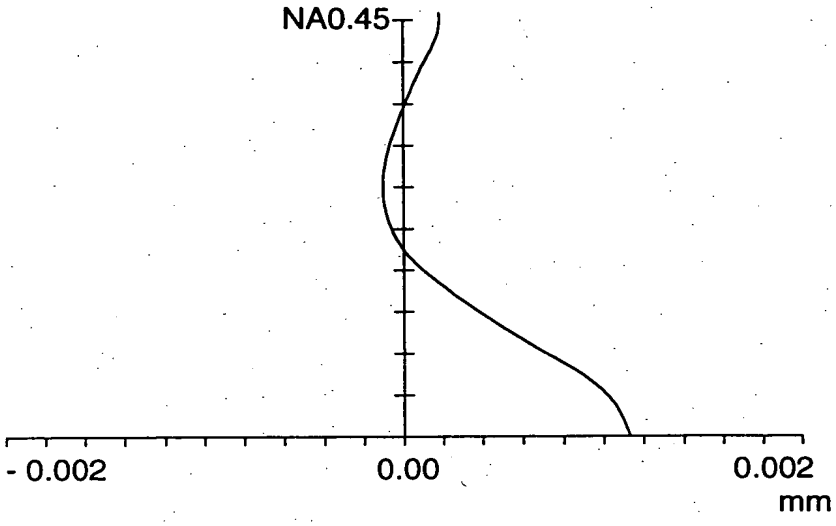


FIG. 4

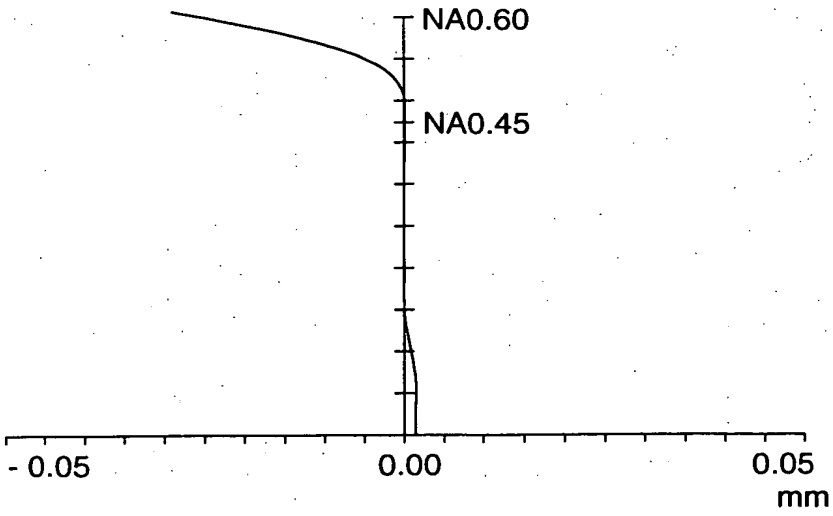


FIG. 5

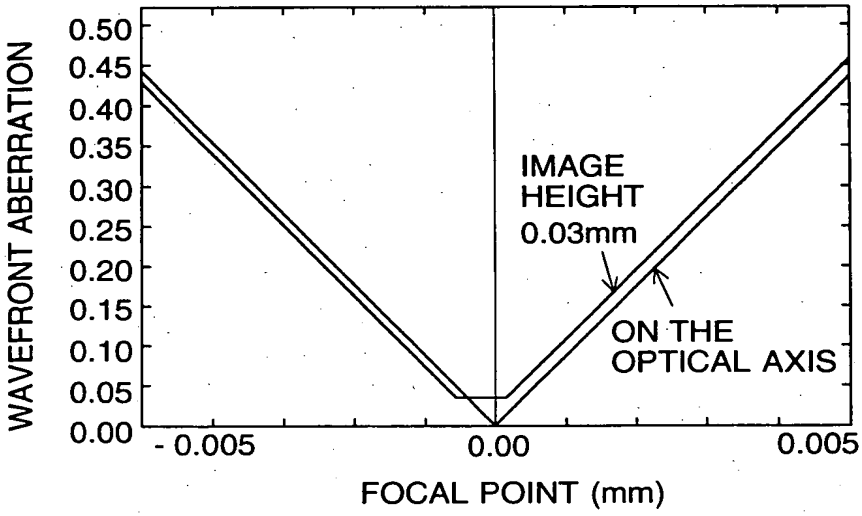

WAVEFRONT ABERRATION
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
IMAGE
HEIGHT
0.03mm
ON THE
OPTICAL AXIS
- 0.005
0.00
0.005
FOCAL POINT (mm)

FIG. 6

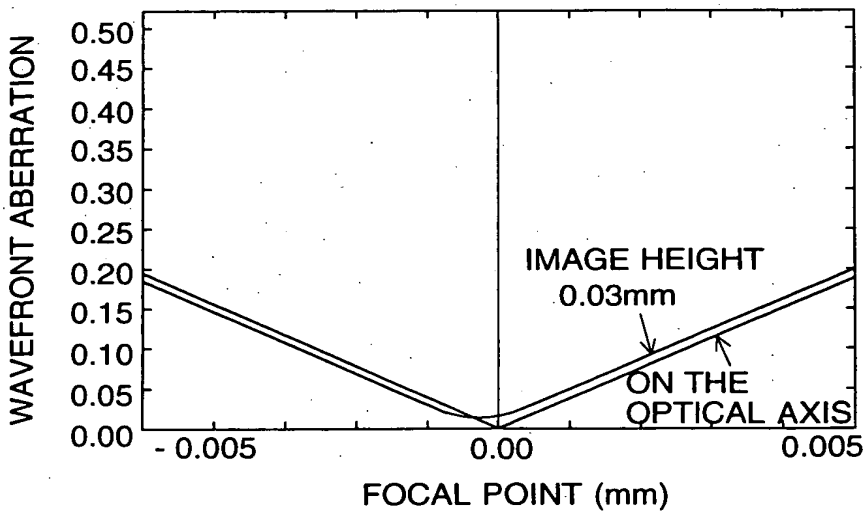

WAVEFRONT ABERRATION
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
IMAGE HEIGHT
0.03mm
ON THE
OPTICAL AXIS
- 0.005
0.00
0.005
FOCAL POINT (mm)

FIG. 7

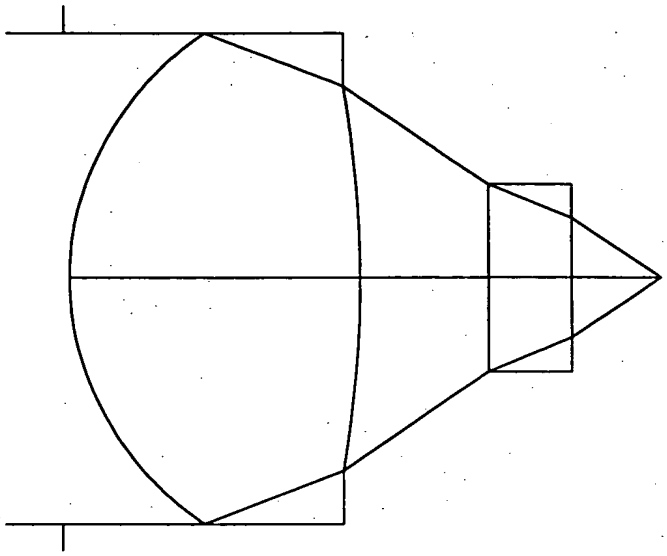


FIG. 8

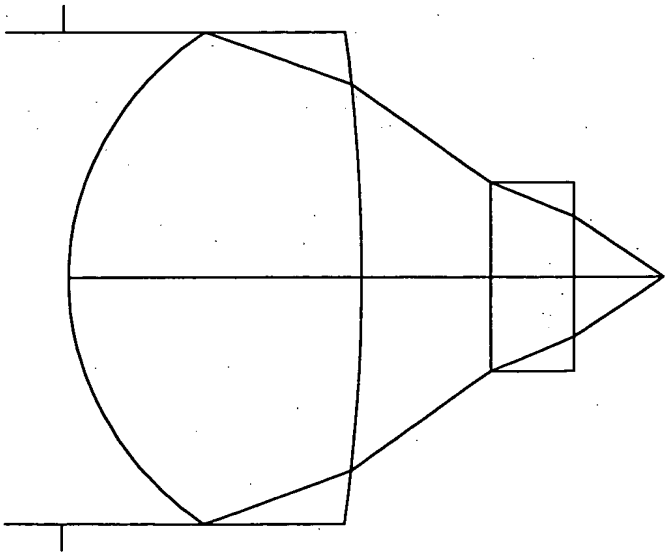


FIG. 9

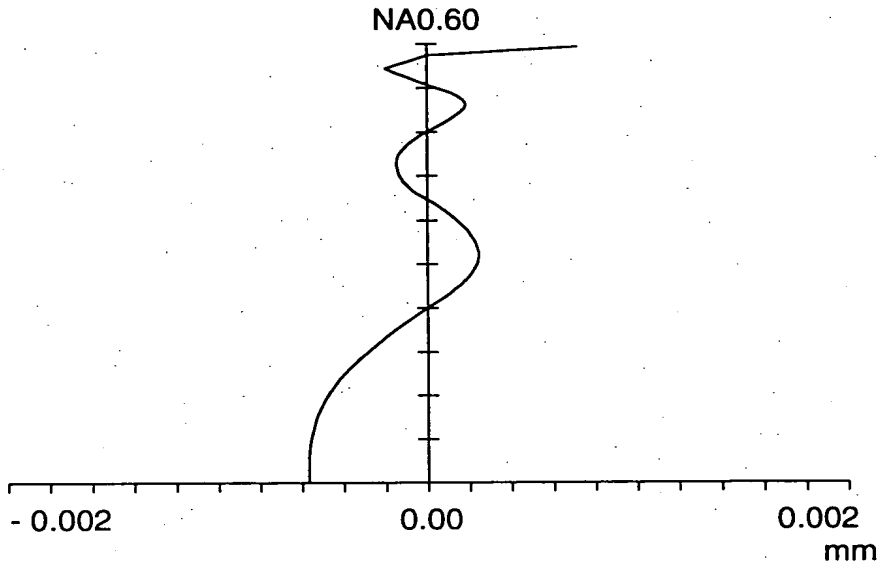


FIG. 10

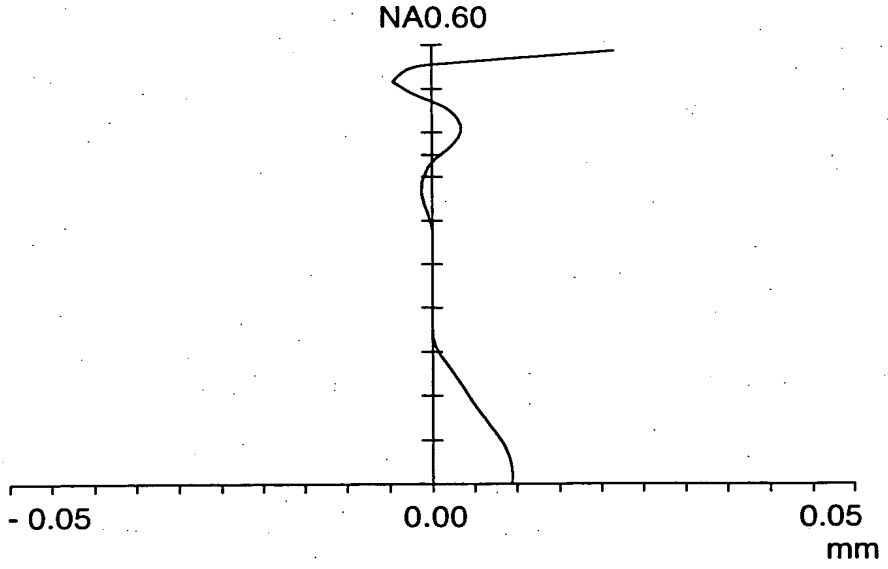


FIG. 11

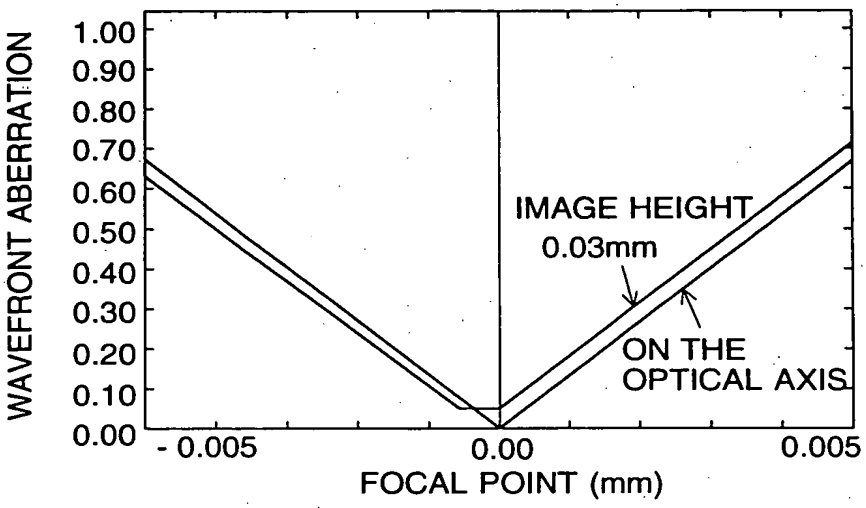

WAVEFRONT ABERRATION
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
IMAGE HEIGHT
0.03mm
ON THE
OPTICAL AXIS
- 0.005
0.00
0.005
FOCAL POINT (mm)

FIG. 12

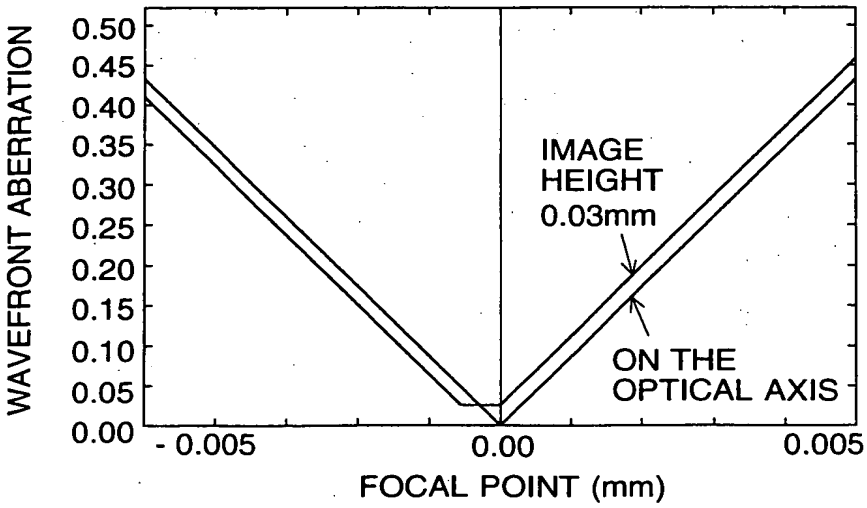

WAVEFRONT ABERRATION
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
IMAGE
HEIGHT
0.03mm
ON THE
OPTICAL AXIS
- 0.005
0.00
0.005
FOCAL POINT (mm)

FIG. 13

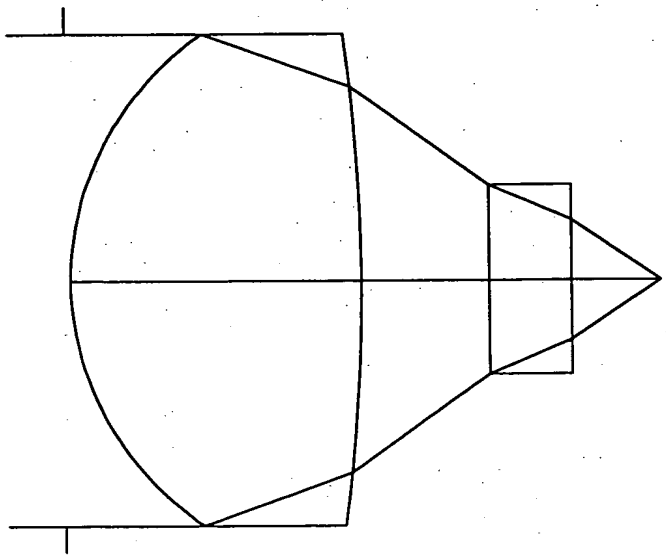


FIG. 14

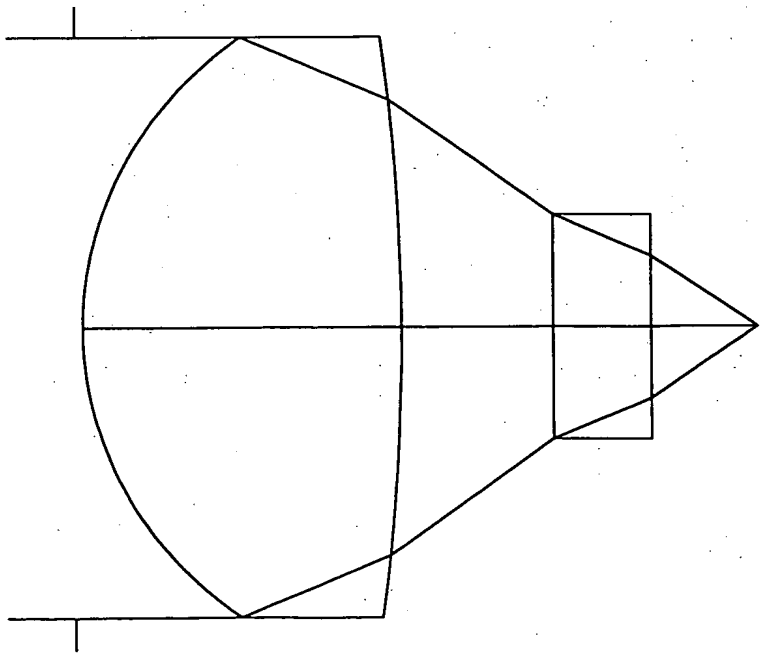


FIG. 15

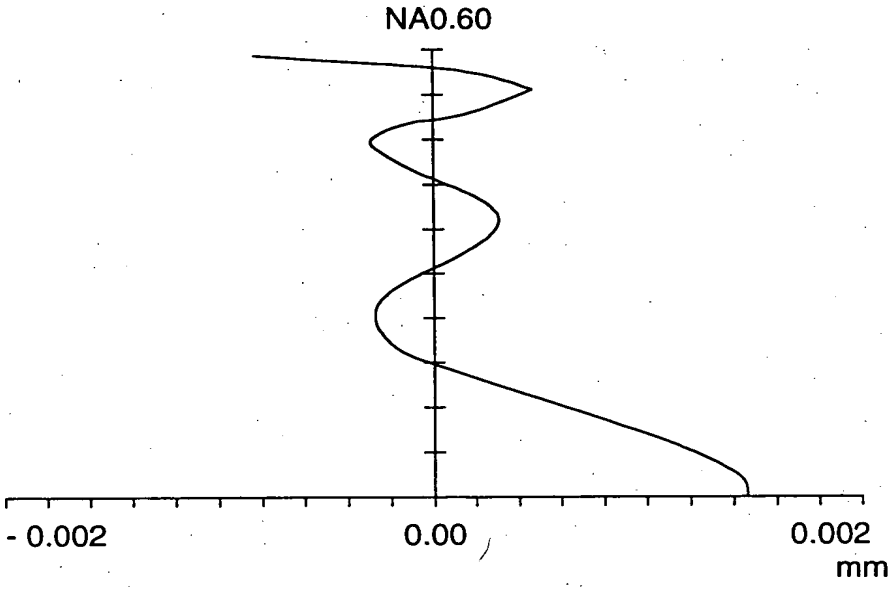


FIG. 16

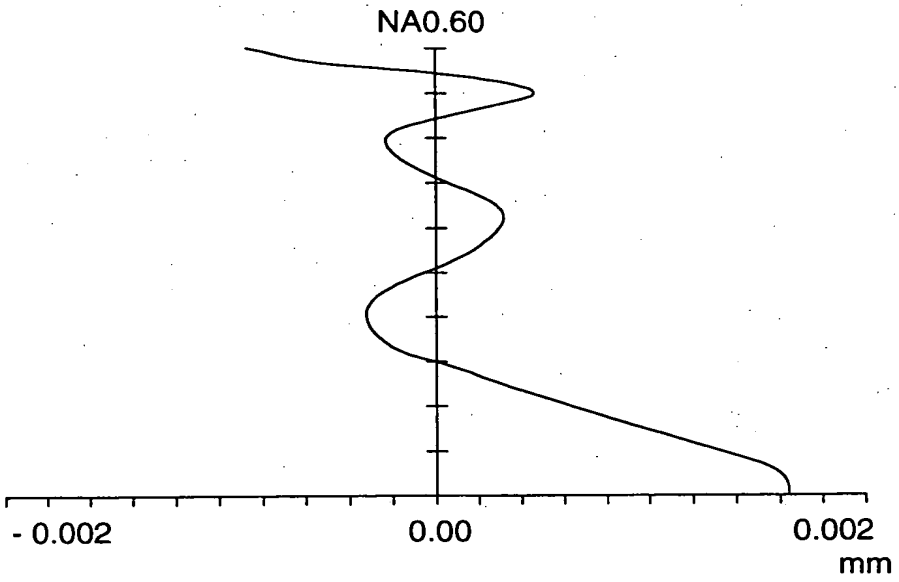


FIG. 17

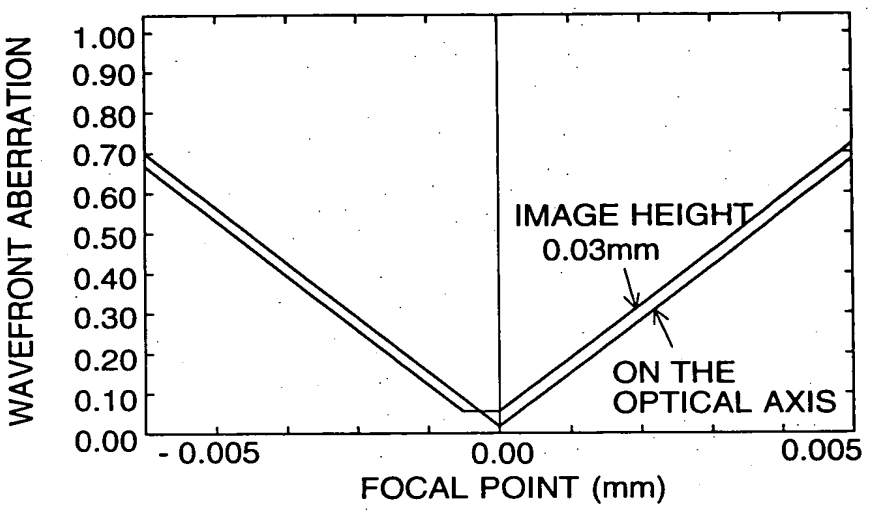

WAVEFRONT ABERRATION
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
IMAGE HEIGHT
0.03mm
ON THE
OPTICAL AXIS
- 0.005
0.00
0.005
FOCAL POINT (mm)

FIG. 18

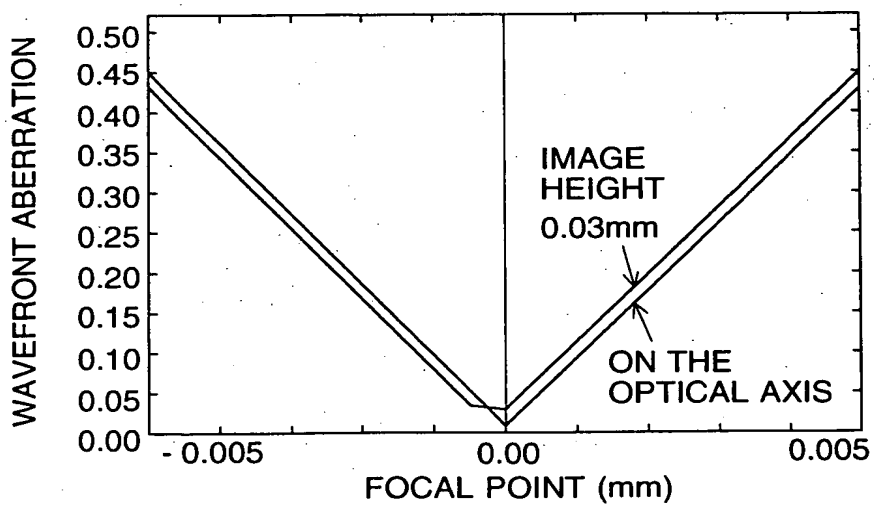

WAVEFRONT ABERRATION
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
IMAGE
HEIGHT
0.03mm
ON THE
OPTICAL AXIS
- 0.005
0.00
0.005
FOCAL POINT (mm)

FIG. 19

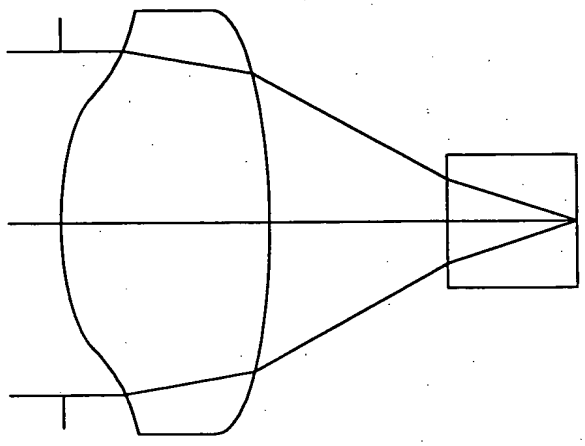


FIG. 20

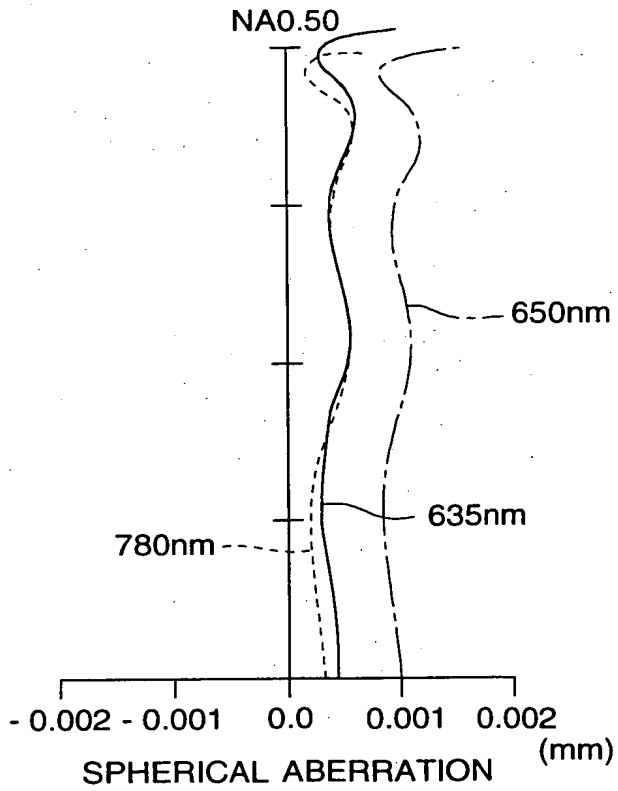

NA0.50
650nm
635nm
780nm
- 0.002 - 0.001
0.0
0.001
0.002
(mm)
SPHERICAL ABERRATION

FIG. 21

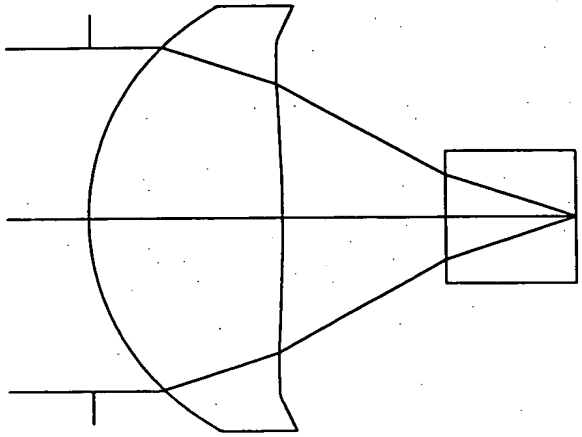


FIG. 22

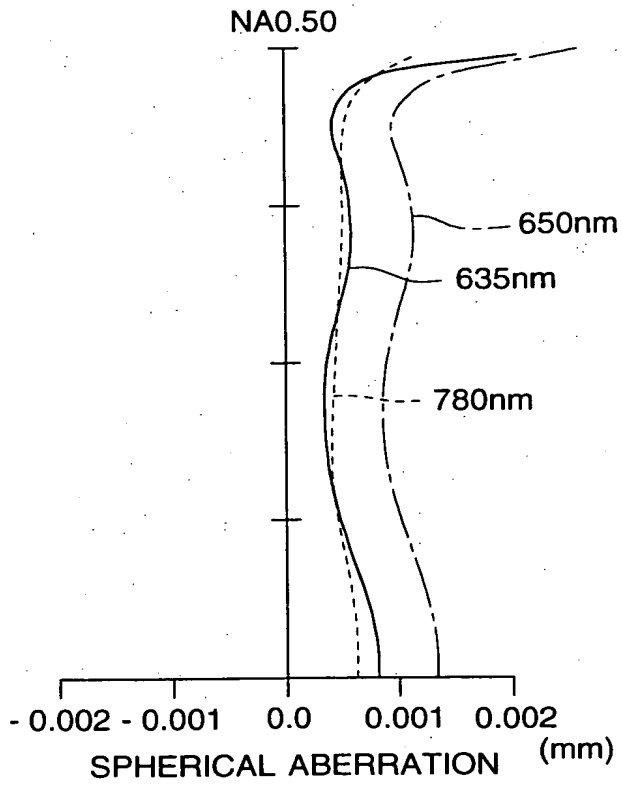

NA0.50
650nm
635nm
780nm
- 0.002
- 0.001
0.0
0.001
0.002
(mm)
SPHERICAL ABERRATION

FIG. 23

CROSS SECTIONAL VIEW OF EXAMPLE 6 AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =650nm

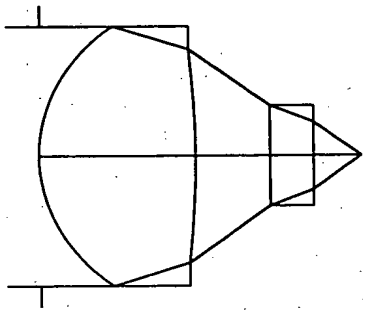


FIG. 24

CROSS SECTIONAL VIEW OF EXAMPLE 6 AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =780nm (NA0.5)

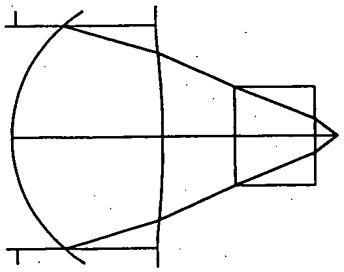


FIG. 25

DIAGRAM SHOWING SPHERICAL ABERRATION
FOR WAVELENGTH λ =650±10nm IN EXAMPLE 6

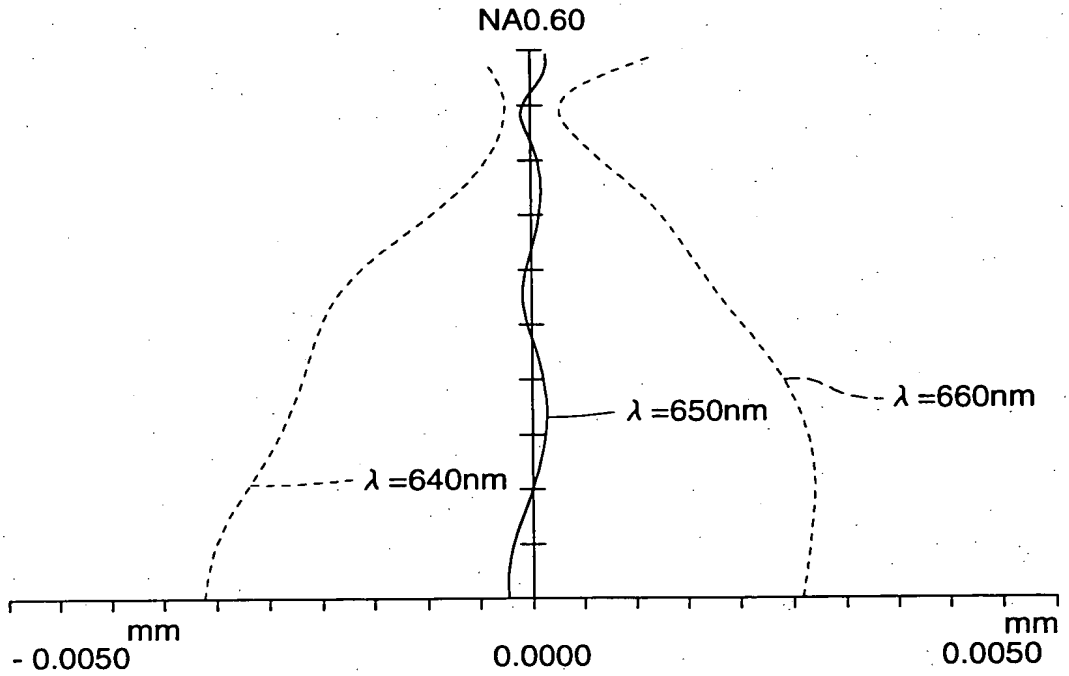


FIG. 26

DIAGRAM SHOWING SPHERICAL ABERRATION (NA0.5)
FOR WAVELENGTH λ =780±10nm IN EXAMPLE 6

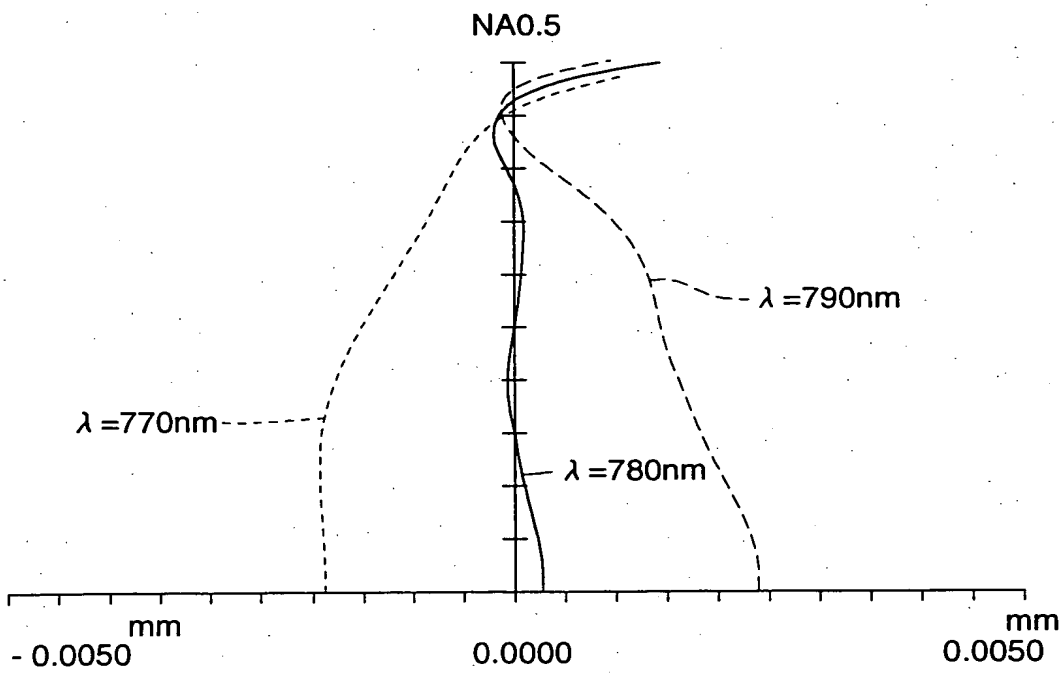


FIG. 27

DIAGRAM SHOWING SPHERICAL ABERRATION
FOR WAVELENGTH λ =780nm IN EXAMPLE 6

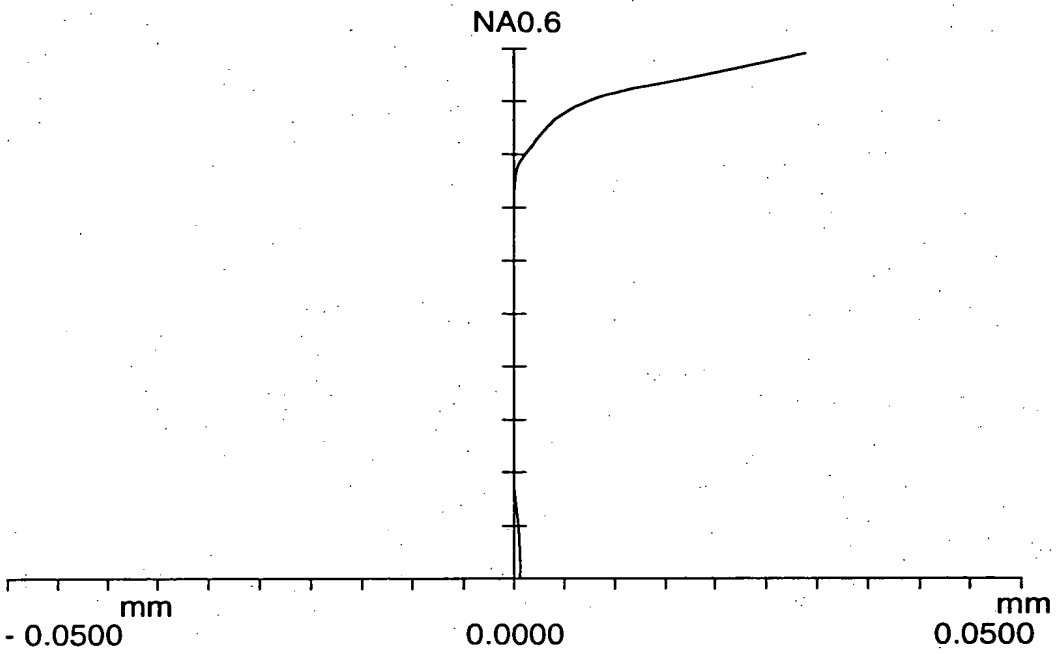


FIG. 28

DIAGRAM SHOWING WAVEFRONT ABERRATION RMS
FOR WAVELENGTH λ =650nm IN EXAMPLE 6

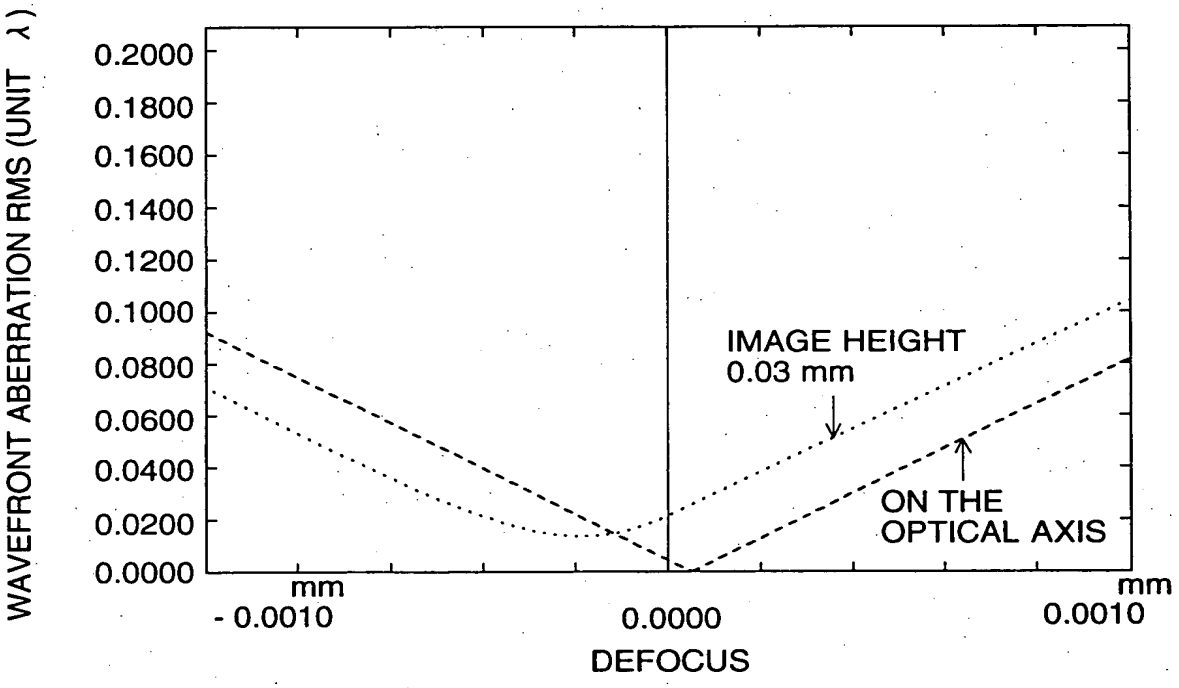


FIG. 29

DIAGRAM SHOWING WAVEFRONT ABERRATION RMS FOR WAVELENGTH λ =780nm (NA0.5) IN EXAMPLE 6

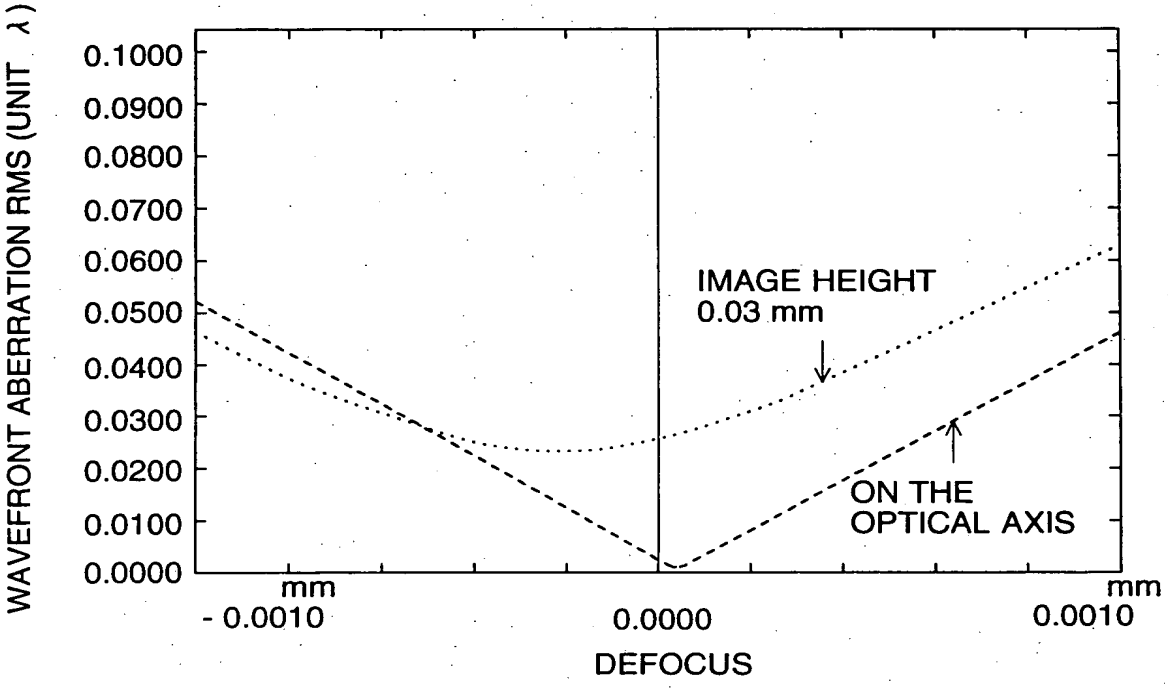


FIG. 30

CROSS SECTIONAL VIEW OF EXAMPLE 7 AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =650nm

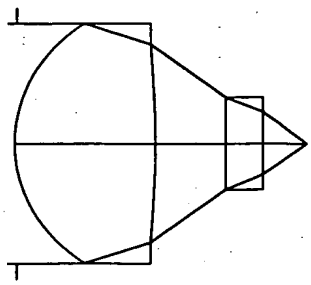


FIG. 31

CROSS SECTIONAL VIEW OF EXAMPLE 7 AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =780nm (NA0.5)

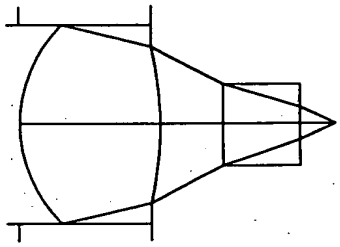


FIG. 32

DIAGRAM SHOWING SPHERICAL ABERRATION FOR WAVELENGTH λ =650±10nm IN EXAMPLE 7

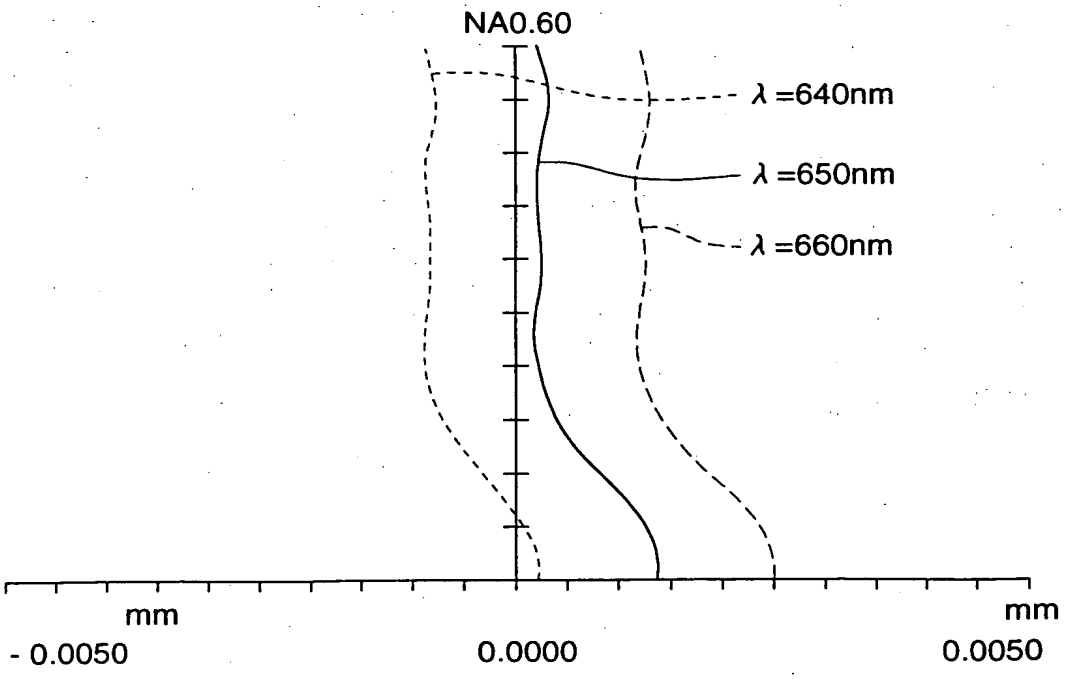


FIG. 33

DIAGRAM SHOWING SPHERICAL ABERRATION (NA0.50)
FOR WAVELENGTH λ =780±10nm IN EXAMPLE 7

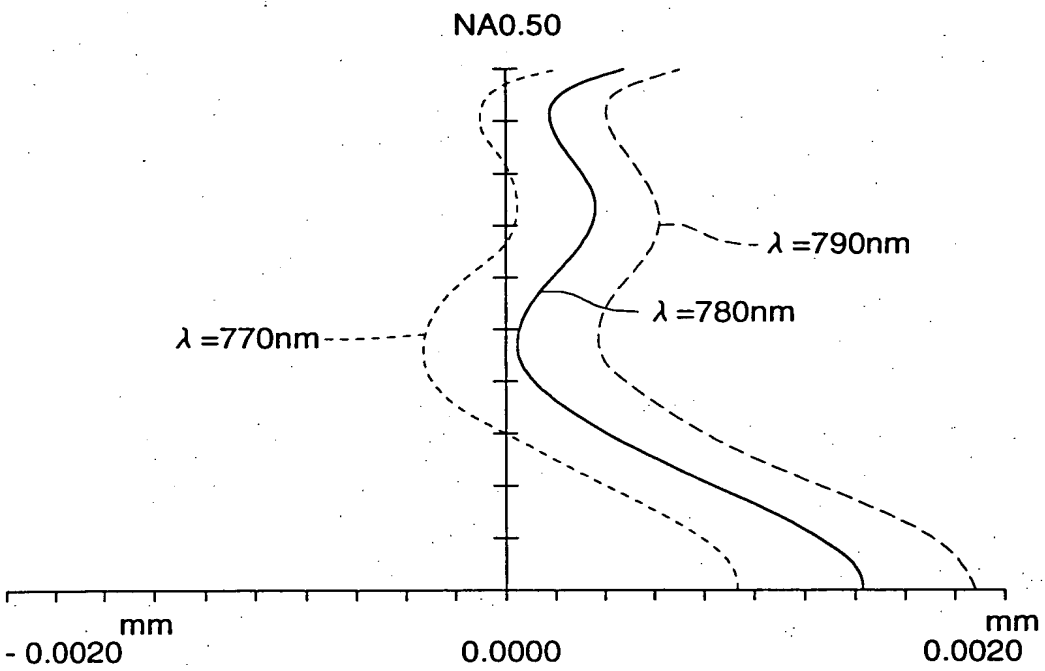


FIG. 34

DIAGRAM SHOWING SPHERICAL ABERRATION
FOR WAVELENGTH λ =780nm (NA0.60) IN EXAMPLE 7

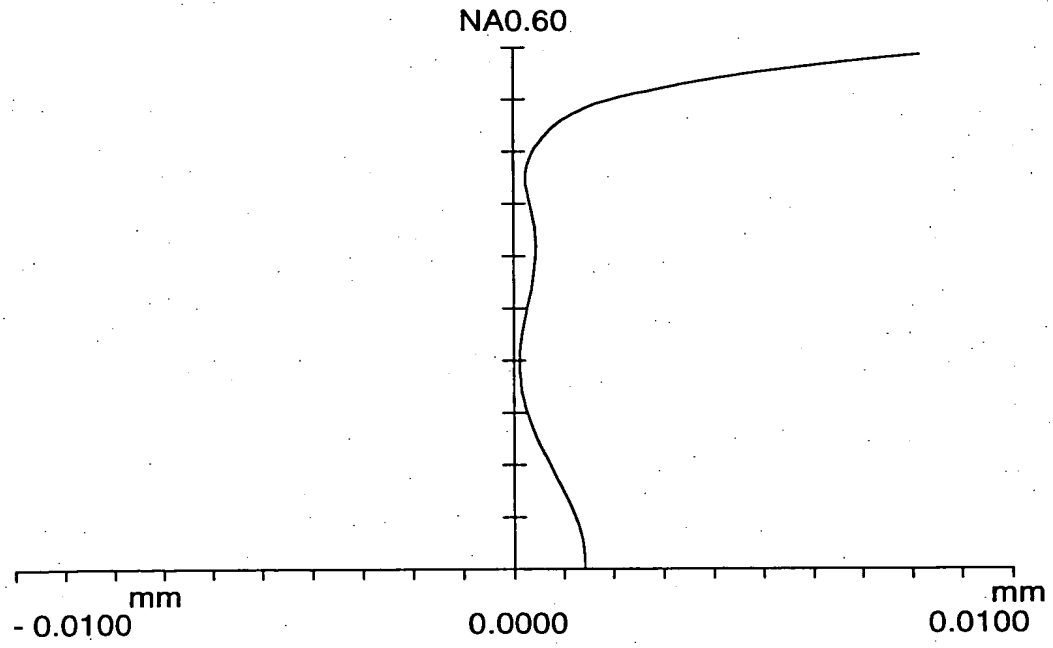


FIG. 35

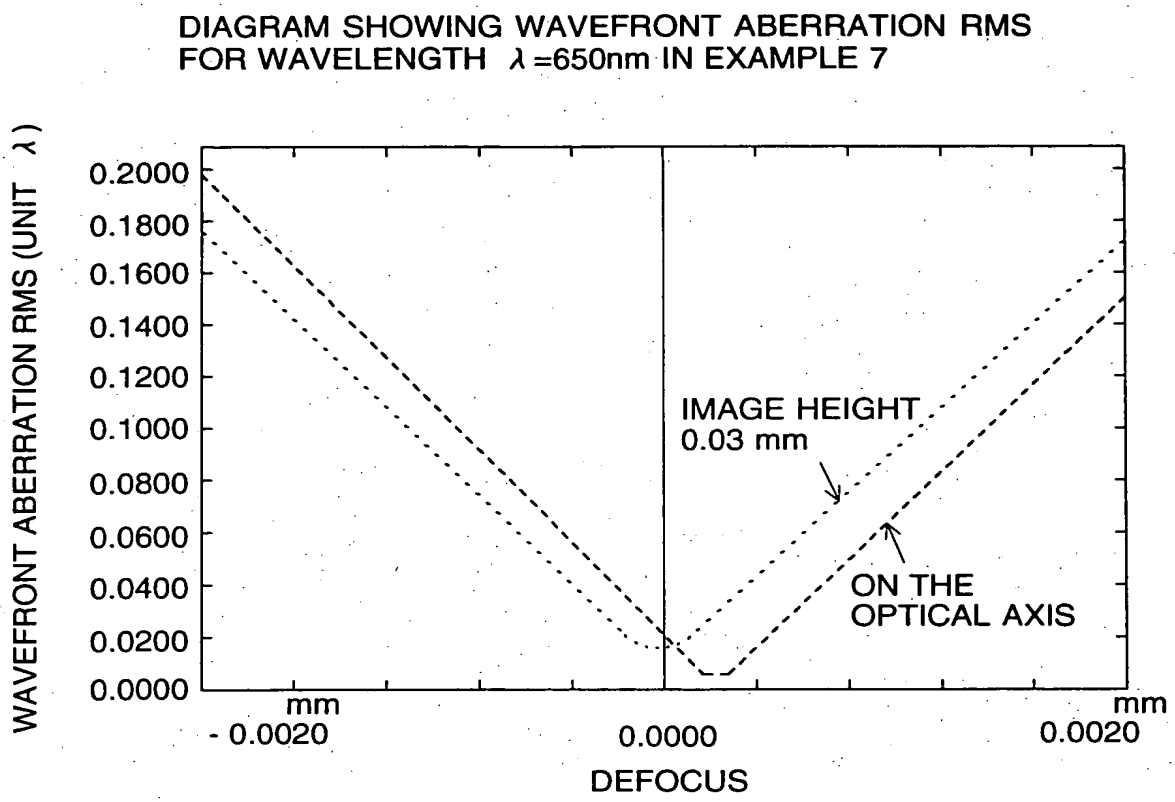


DIAGRAM SHOWING WAVEFRONT ABERRATION RMS
FOR WAVELENGTH λ=650nm IN EXAMPLE 7
WAVEFRONT ABERRATION RMS (UNIT λ)
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
mm
- 0.0020
0.0000
mm
0.0020
DEFOCUS

FIG. 36

DIAGRAM SHOWING WAVEFRONT ABERRATION RMS FOR WAVELENGTH λ =780nm IN EXAMPLE 7

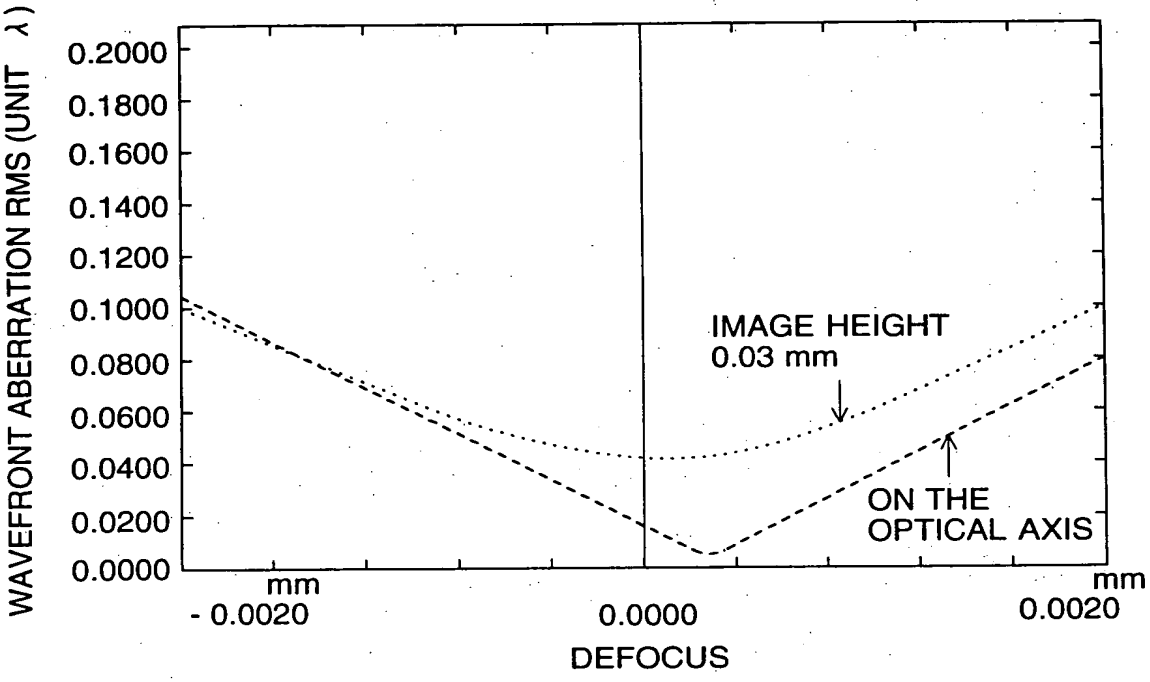


FIG. 37

CROSS SECTIONAL VIEW OF EXAMPLE 8 AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =650nm

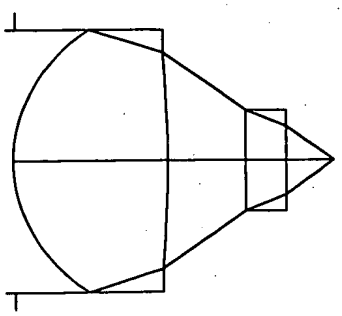


FIG. 38

CROSS SECTIONAL VIEW OF EXAMPLE 8 AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =780nm

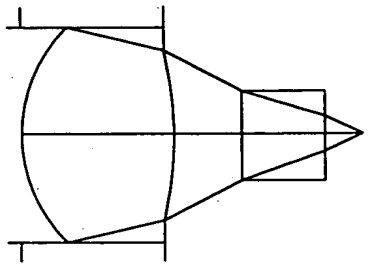


FIG. 39

DIAGRAM SHOWING SPHERICAL ABERRATION FOR WAVELENGTH λ =650±10nm IN EXAMPLE 8

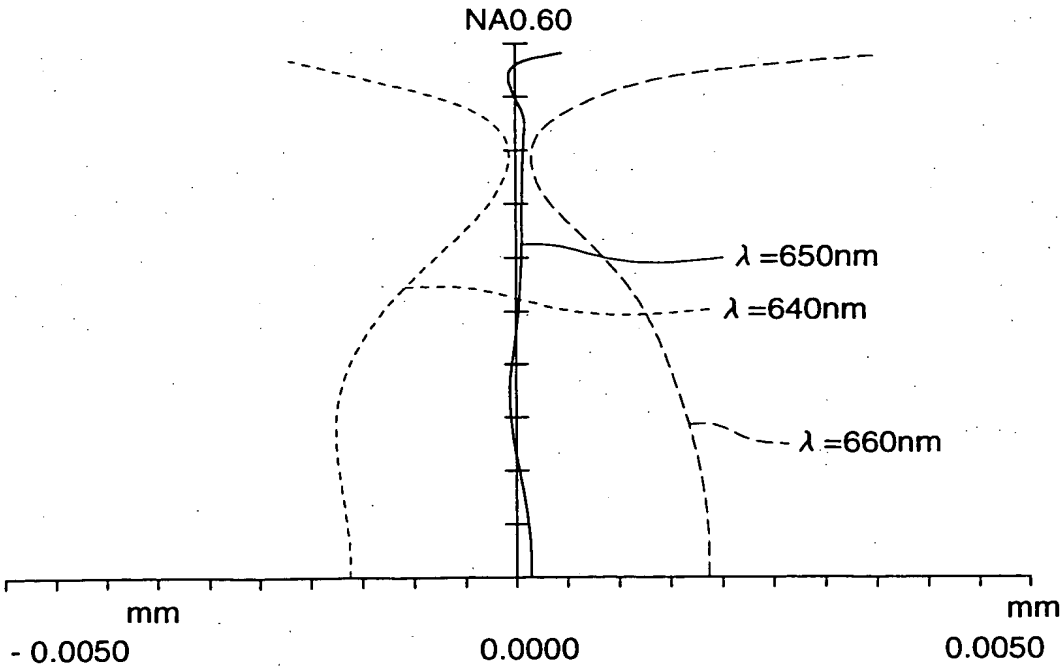


FIG. 40

DIAGRAM SHOWING SPHERICAL ABERRATION
FOR WAVELENGTH λ =780±10nm IN EXAMPLE 8

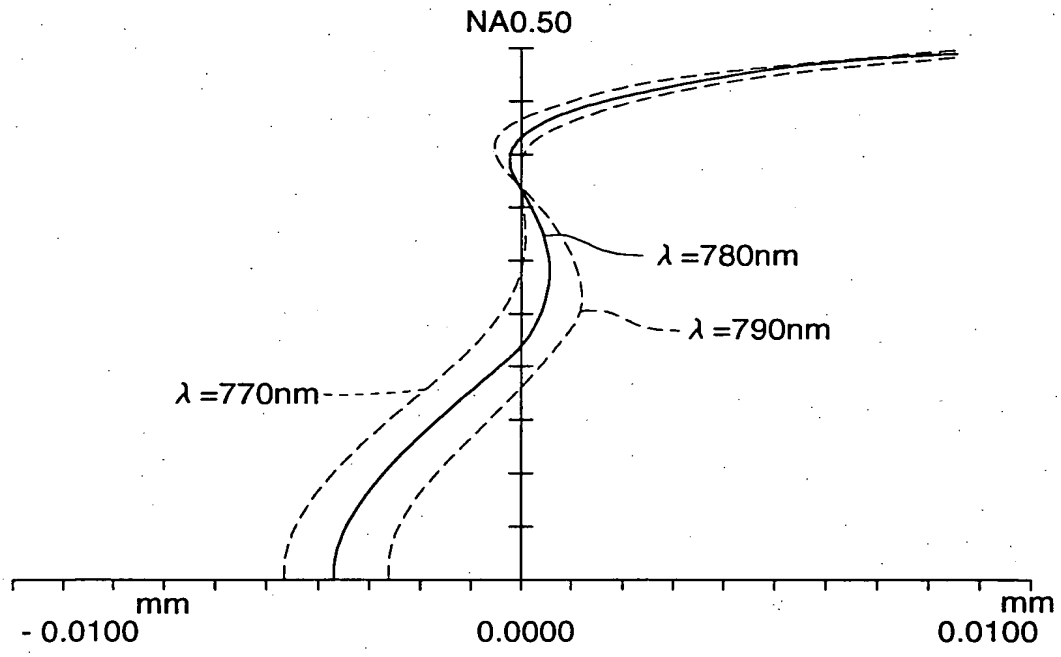


FIG. 41

DIAGRAM SHOWING SPHERICAL ABERRATION
FOR WAVELENGTH λ =780nm (NA0.60) IN EXAMPLE 8

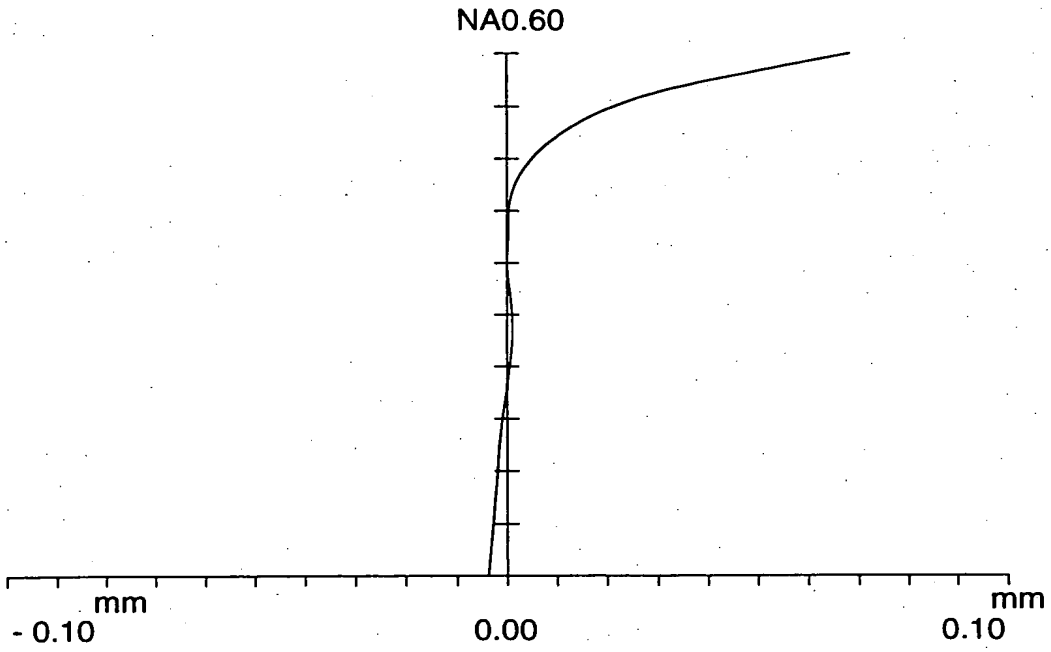


FIG. 42

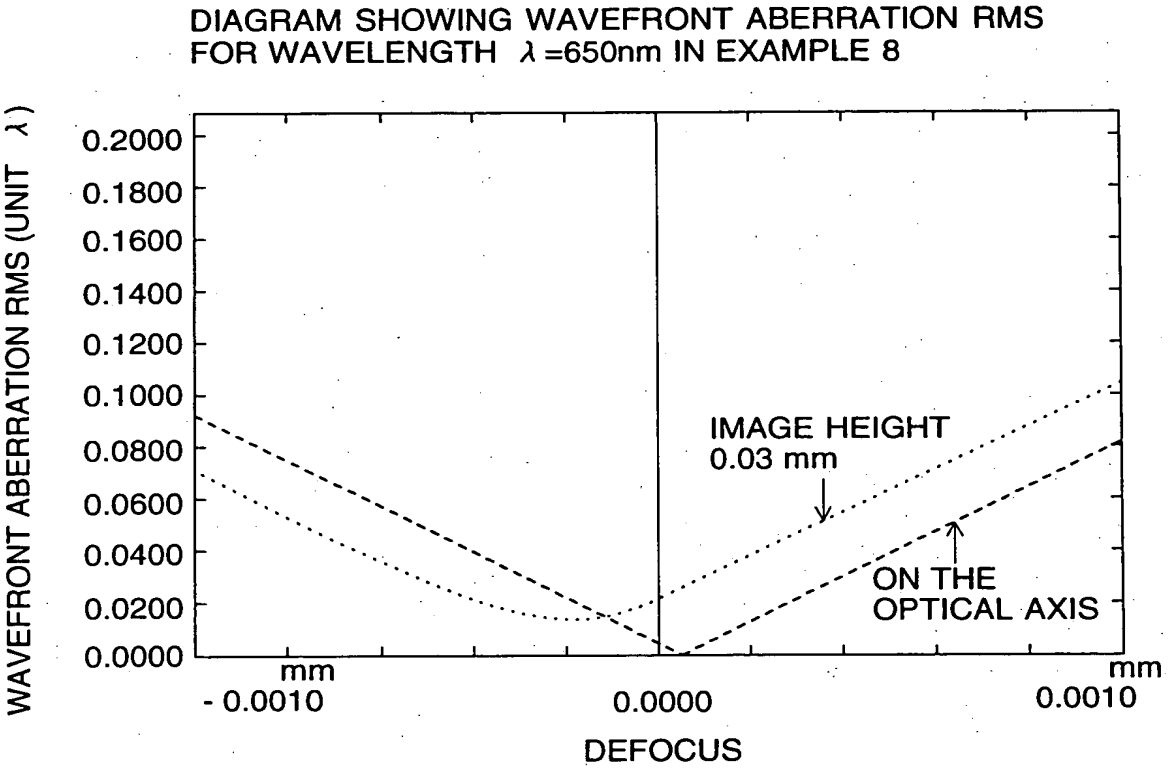


DIAGRAM SHOWING WAVEFRONT ABERRATION RMS
FOR WAVELENGTH λ =650nm IN EXAMPLE 8
WAVEFRONT ABERRATION RMS (UNIT λ)
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
mm
- 0.0010
0.0000
mm
0.0010
DEFOCUS

FIG. 43

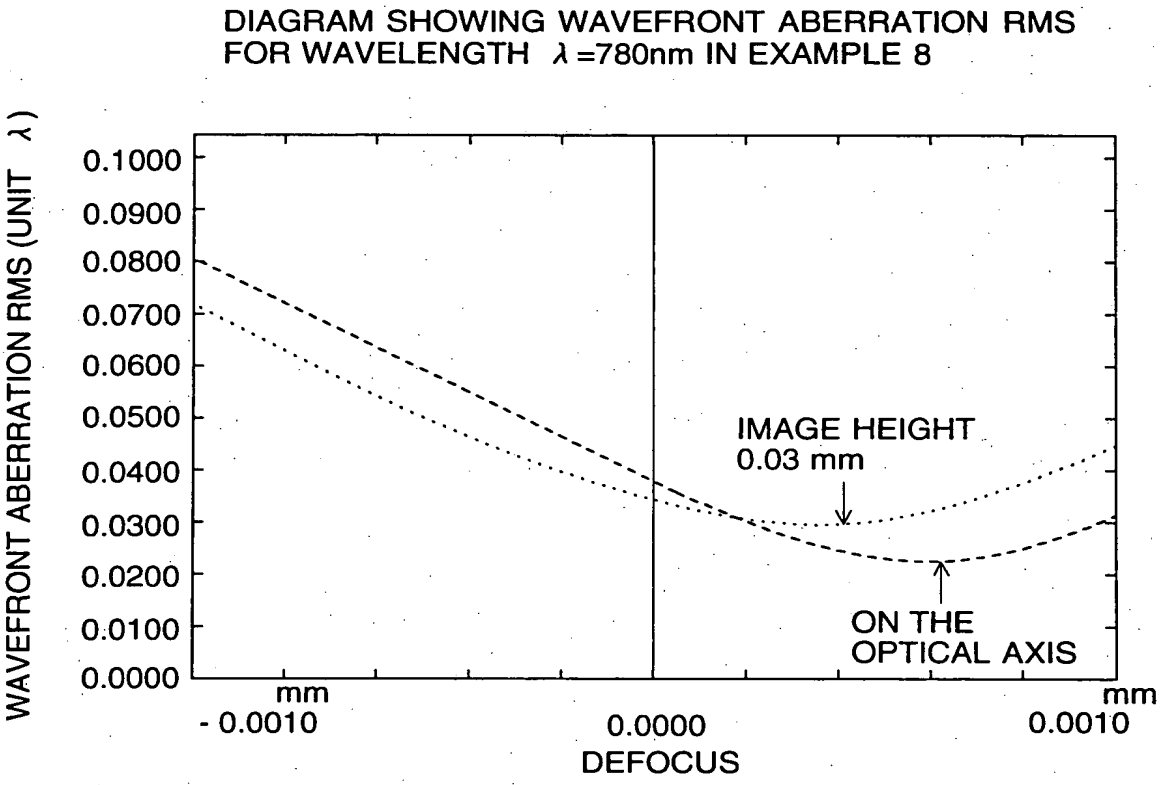


DIAGRAM SHOWING WAVEFRONT ABERRATION RMS
FOR WAVELENGTH λ =780nm IN EXAMPLE 8
WAVEFRONT ABERRATION RMS (UNIT λ)
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
mm
- 0.0010
0.0000
DEFOCUS
mm
0.0010

FIG. 44

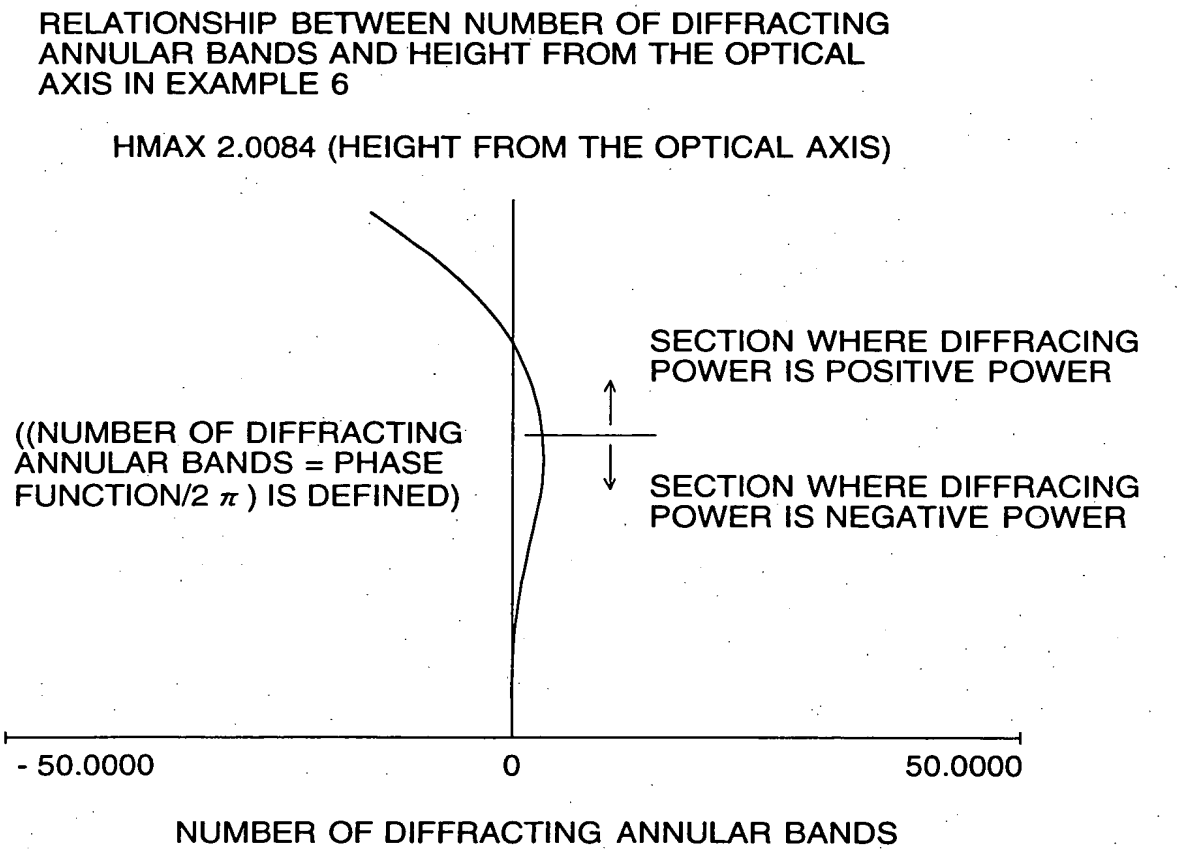

RELATIONSHIP BETWEEN NUMBER OF DIFFRACTING ANNULAR BANDS AND HEIGHT FROM THE OPTICAL AXIS IN EXAMPLE 6
HMAX 2.0084 (HEIGHT FROM THE OPTICAL AXIS)
SECTION WHERE DIFFRACING POWER IS POSITIVE POWER
((NUMBER OF DIFFRACTING ANNULAR BANDS = PHASE FUNCTION/2 π) IS DEFINED)
SECTION WHERE DIFFRACING POWER IS NEGATIVE POWER
- 50.0000
0
50.0000
NUMBER OF DIFFRACTING ANNULAR BANDS

FIG. 45

RELATIONSHIP BETWEEN NUMBER OF DIFFRACTING ANNULAR BANDS AND HEIGHT FROM THE OPTICAL AXIS IN EXAMPLE 7

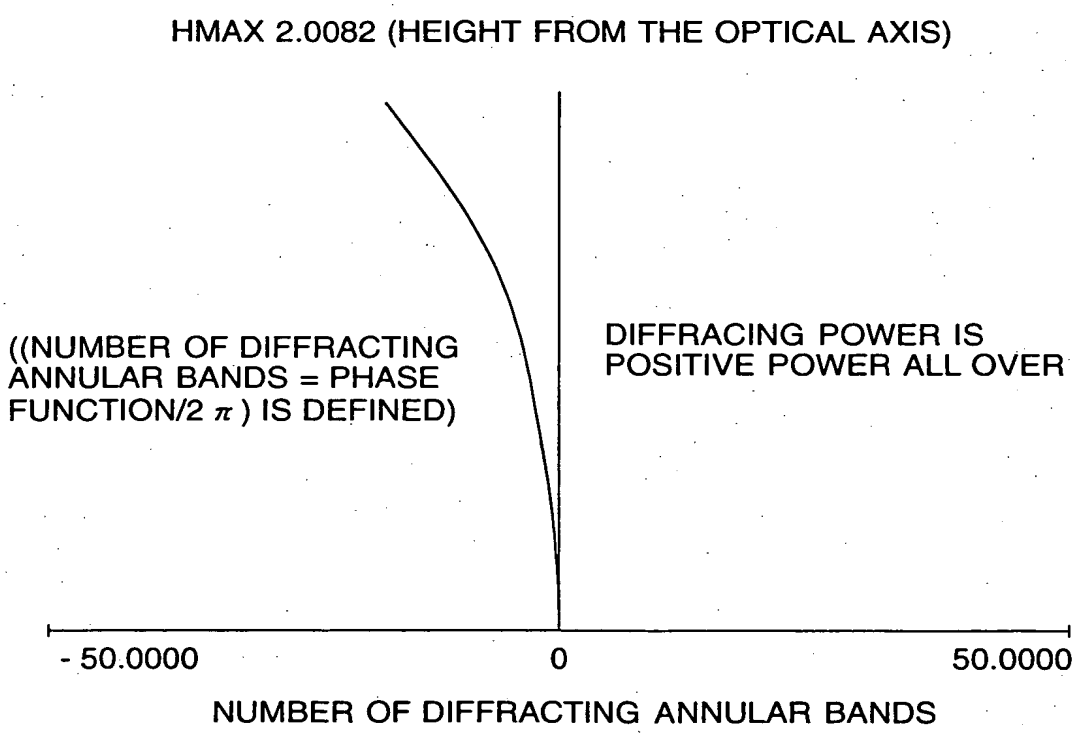


FIG. 46

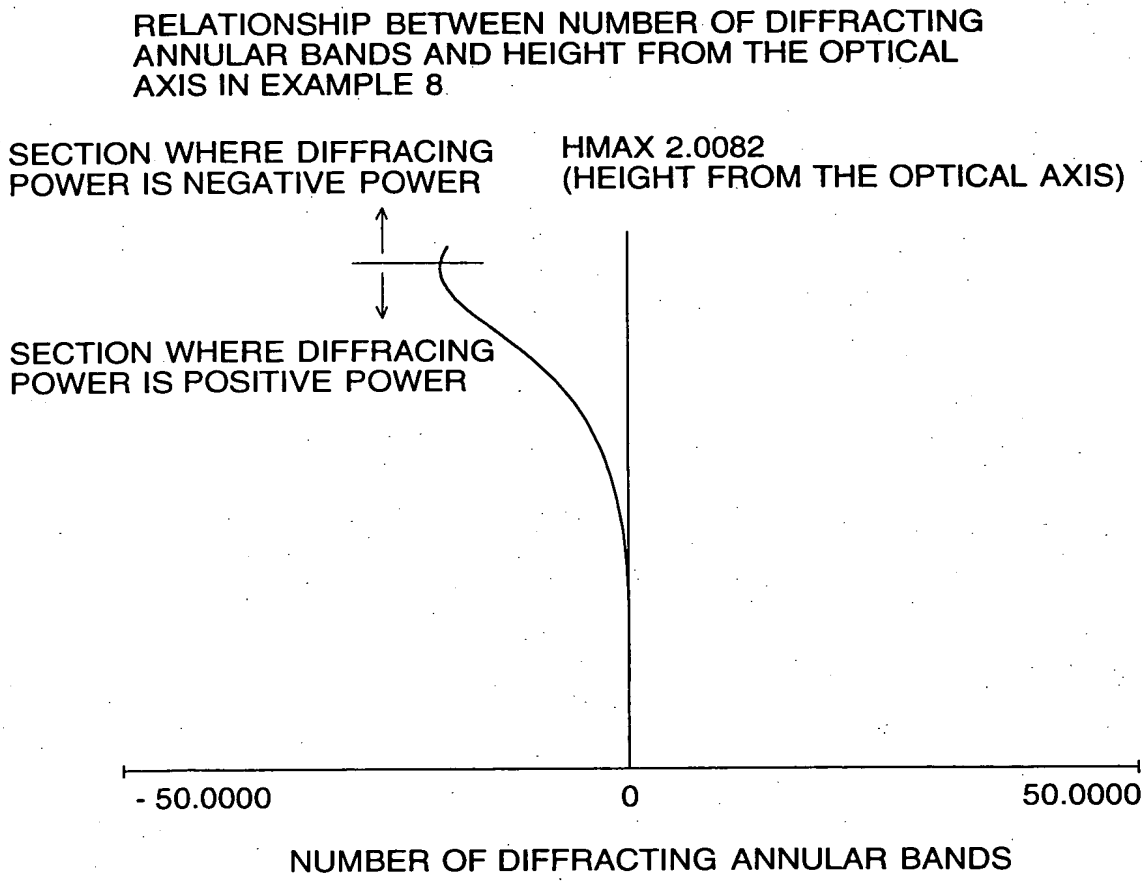
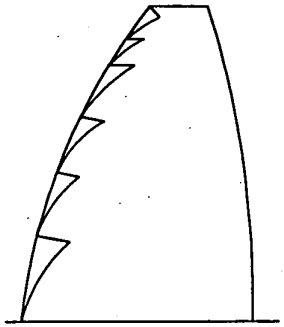
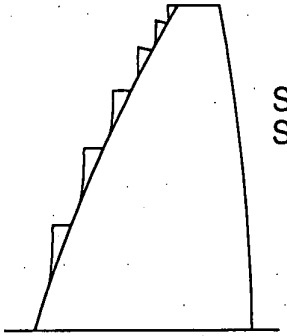

RELATIONSHIP BETWEEN NUMBER OF DIFFRACTING ANNULAR BANDS AND HEIGHT FROM THE OPTICAL AXIS IN EXAMPLE 8
SECTION WHERE DIFFRACING POWER IS NEGATIVE POWER
HMAX 2.0082
(HEIGHT FROM THE OPTICAL AXIS)
SECTION WHERE DIFFRACING POWER IS POSITIVE POWER
- 50.0000
0
50.0000
NUMBER OF DIFFRACTING ANNULAR BANDS

FIG. 47 (a)



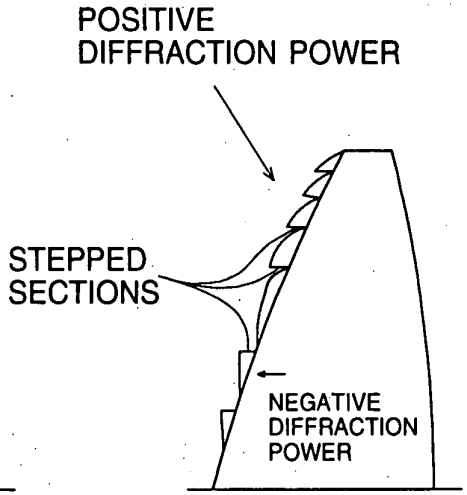
POSITIVE DIFFRACTION POWER

FIG. 47 (b)



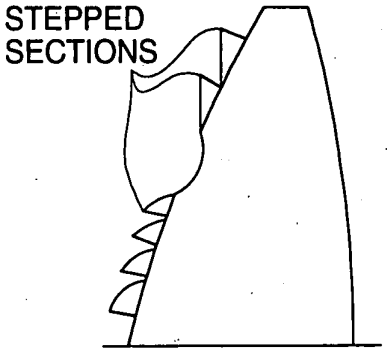
NEGATIVE DIFFRACTION POWER

FIG. 47 (c)



LENS IN WHICH DIFFRACTION POWER IS NEGATIVE POWER IN THE VICINITY OF OPTICAL AXIS AND IS CHANGED TO POSITIVE POWER FROM MIDDLE POINT

FIG. 47 (d)



LENS IN WHICH DIFFRACTION POWER IS POSITIVE POWER IN THE VICINITY OF OPTICAL AXIS AND IS CHANGED TO NEGATIVE POWER FROM MIDDLE POINT

RELATIONSHIP BETWEEN DIFFRACTION POWER AND ACTUAL SHAPE

<4235><4236><4237>
<4238><4239>
P31/81

FIG. 48

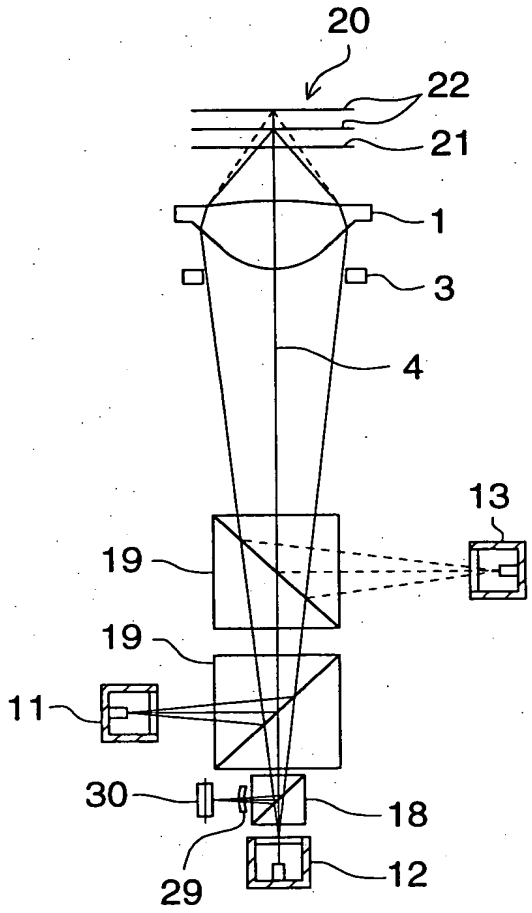


FIG. 49

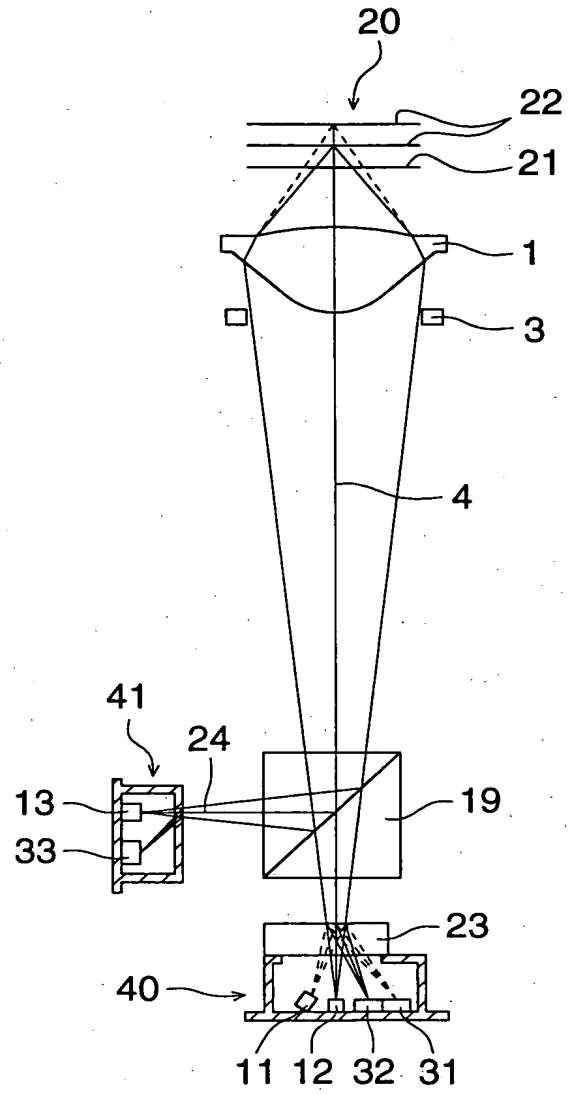


FIG. 50

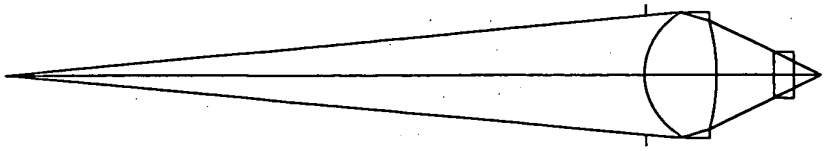


FIG. 51

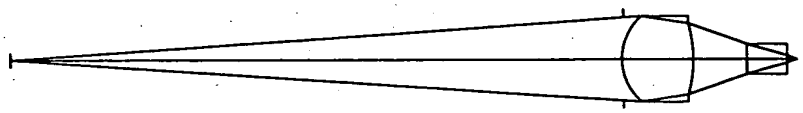


FIG. 52

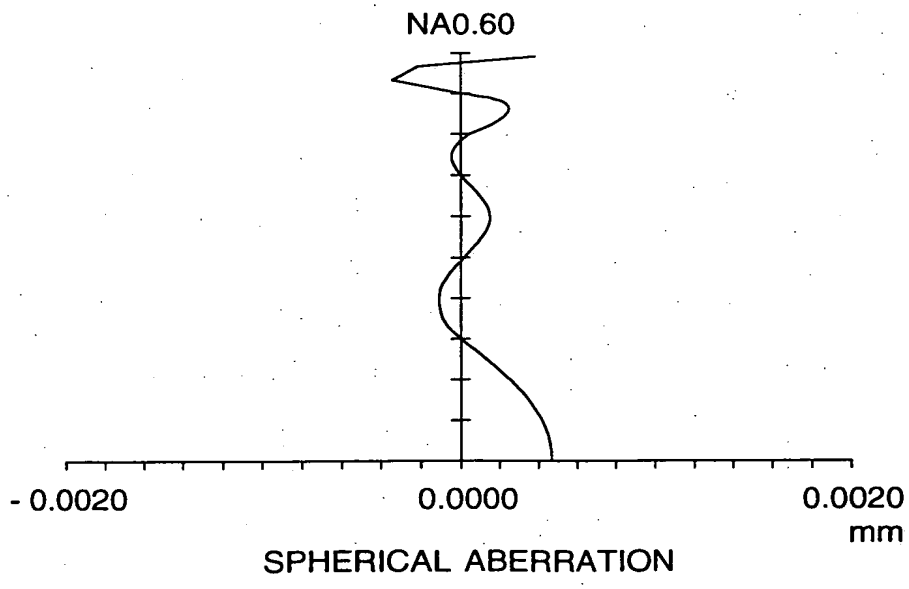


FIG. 53

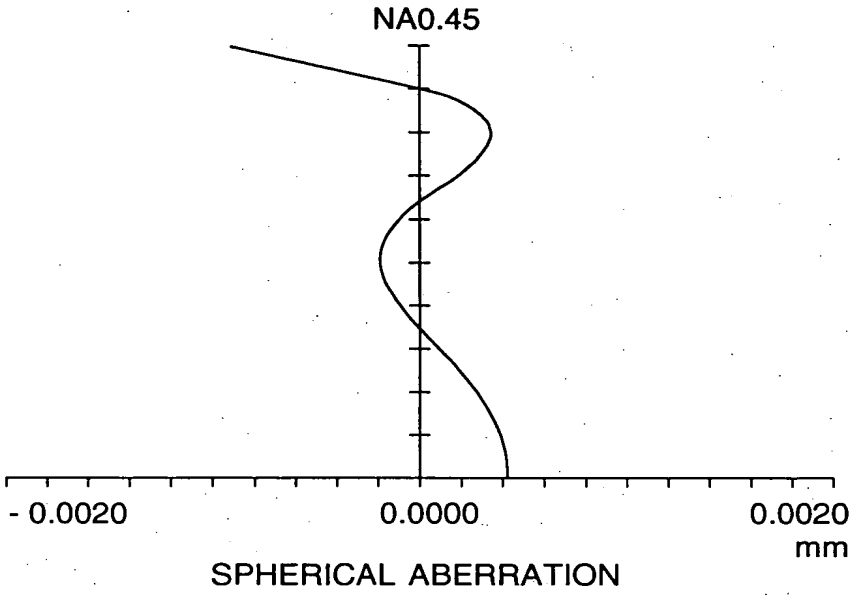

NA0.45
- 0.0020
0.0000
0.0020
mm
SPHERICAL ABERRATION

FIG. 54

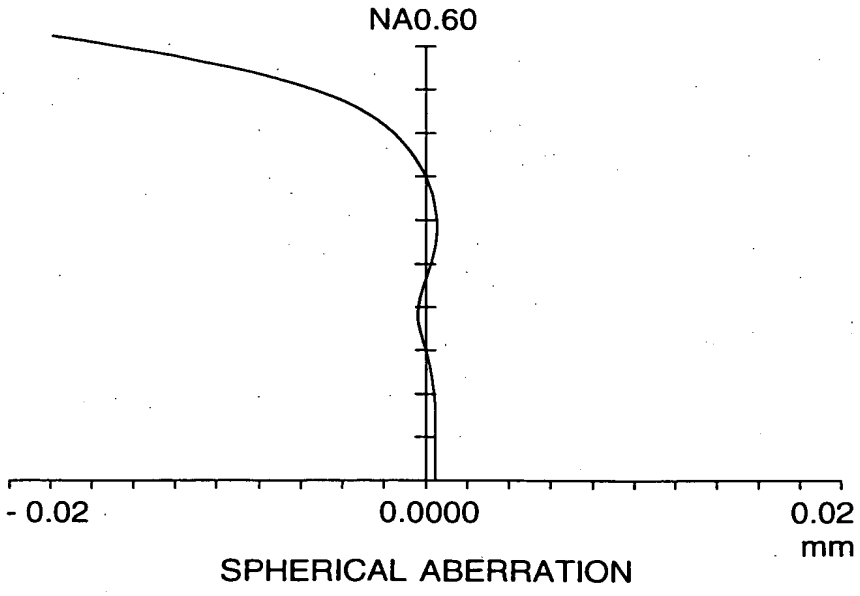

NA0.60
- 0.02
0.0000
0.02
mm
SPHERICAL ABERRATION

FIG. 55

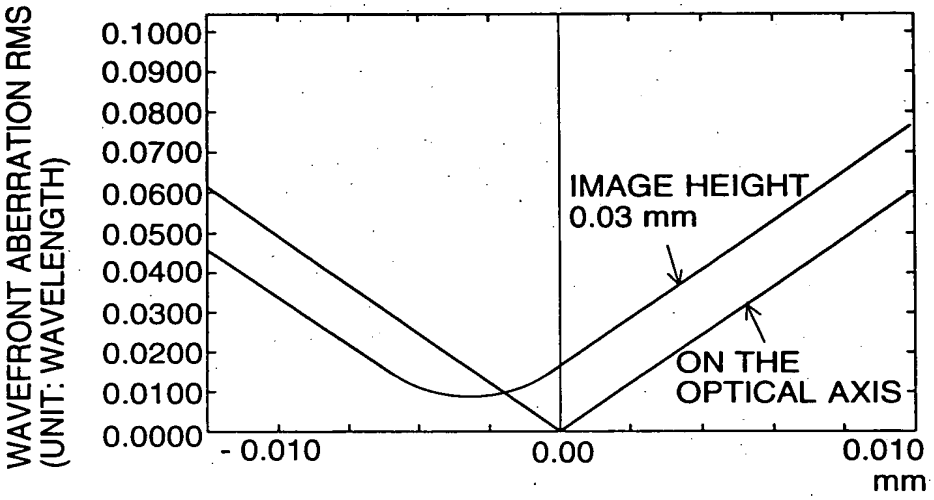

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 56

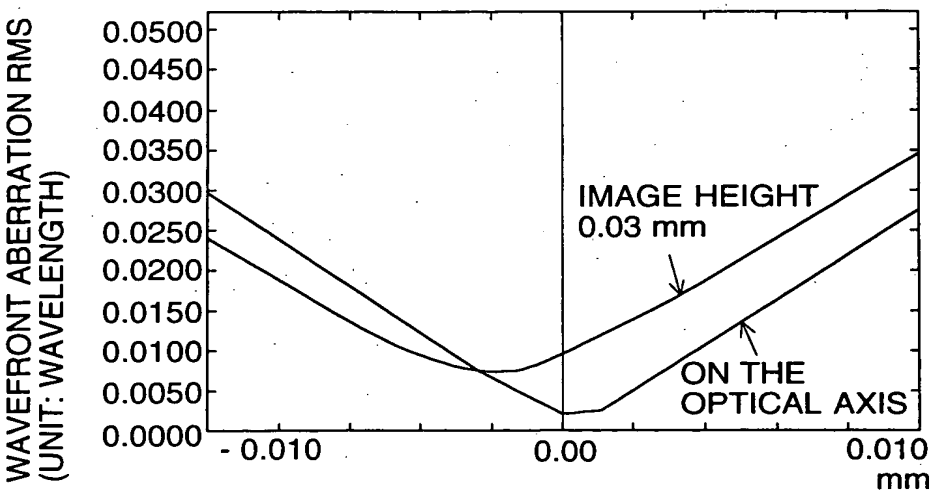

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.0500
0.0450
0.0400
0.0350
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 57

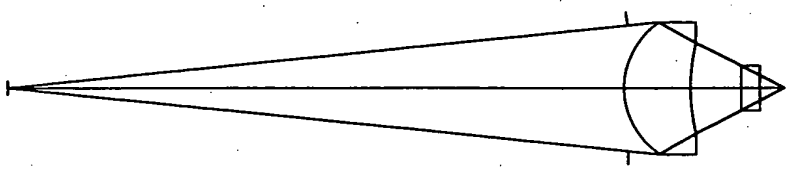


FIG. 58

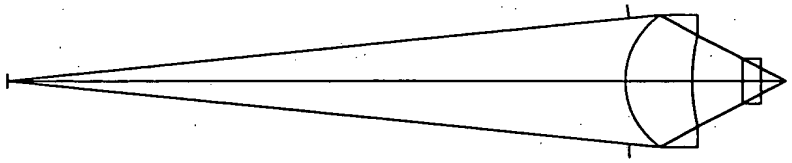


FIG. 59

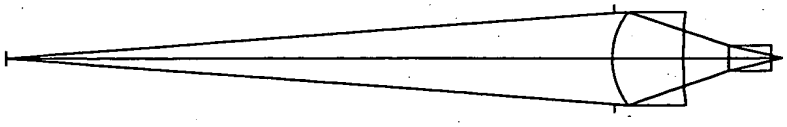


FIG. 60

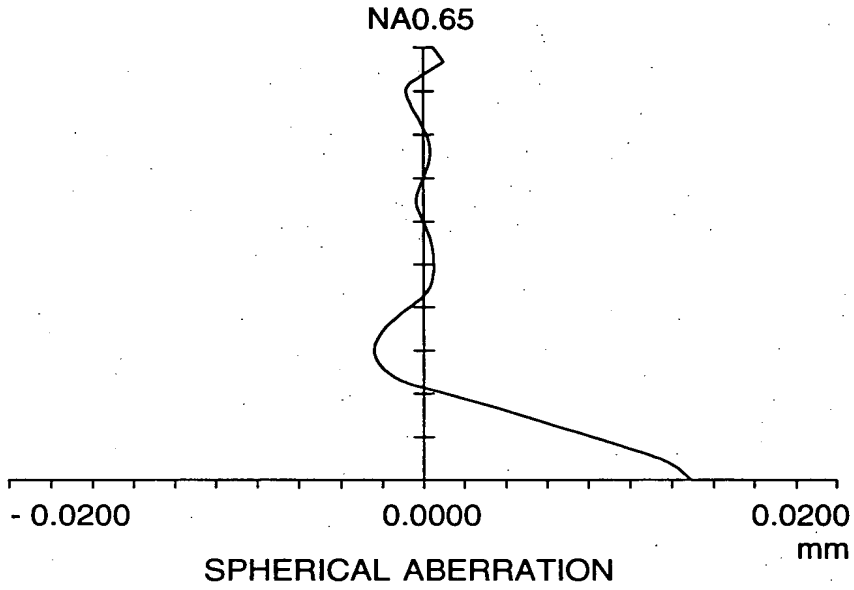

NA0.65
- 0.0200
0.0000
0.0200
mm
SPHERICAL ABERRATION

FIG. 61

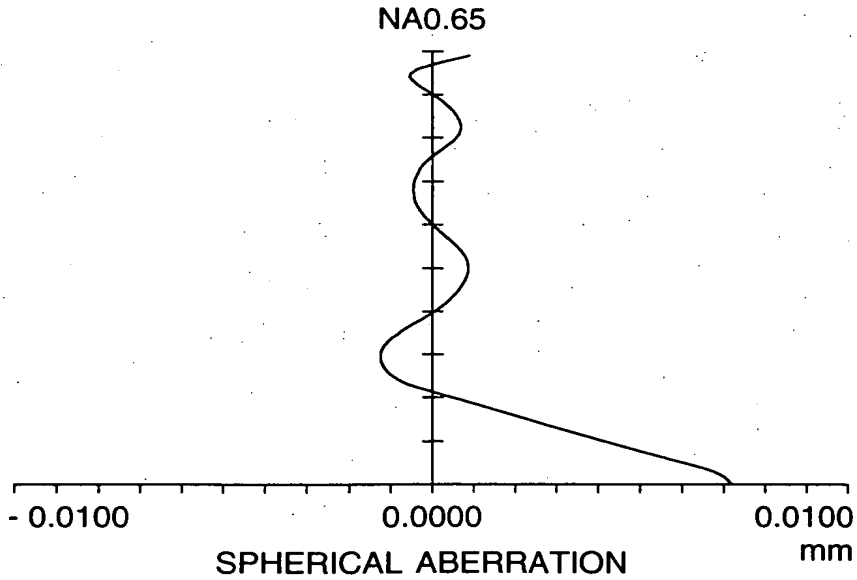

NA0.65
- 0.0100
0.0000
0.0100
mm
SPHERICAL ABERRATION

FIG. 62

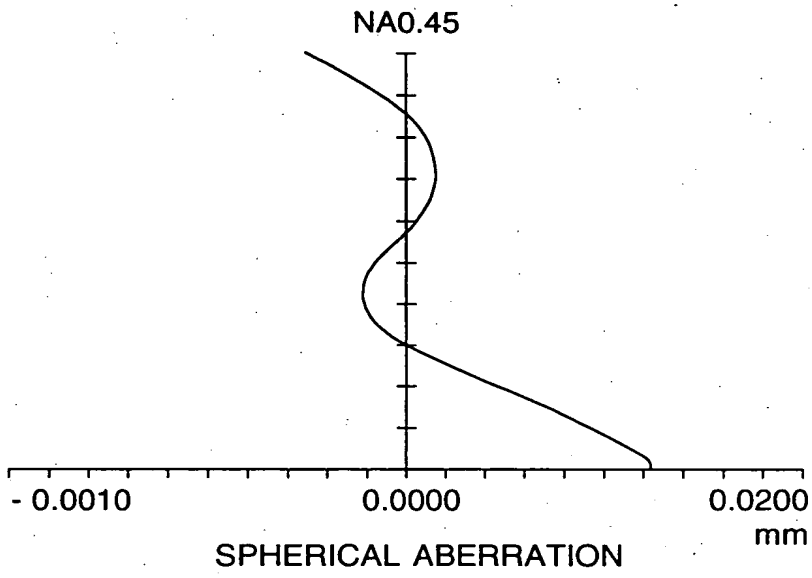

NA0.45
- 0.0010
0.0000
0.0200
mm
SPHERICAL ABERRATION

FIG. 63

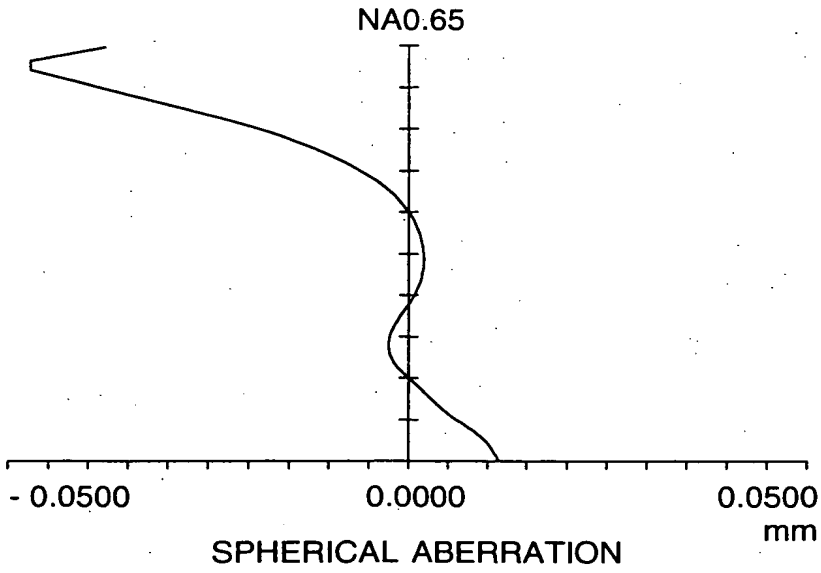

NA0.65
- 0.0500
0.0000
0.0500
mm
SPHERICAL ABERRATION

FIG. 64

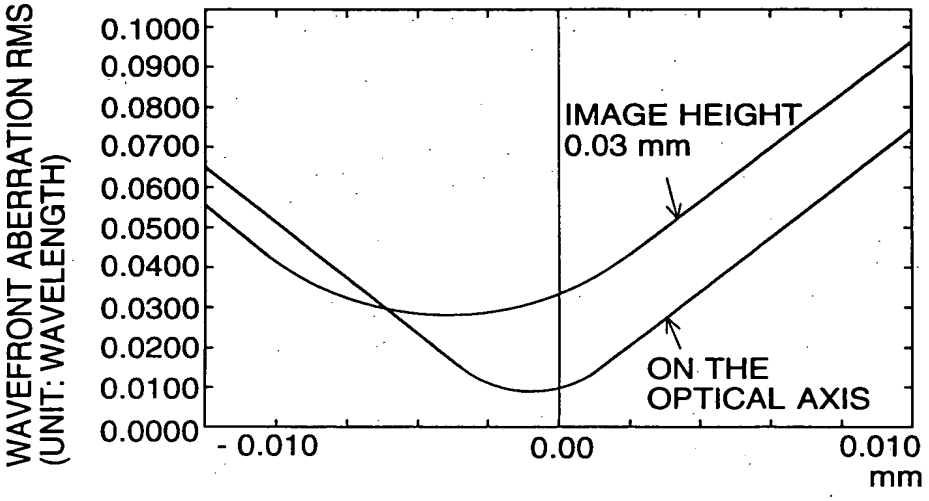

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 65

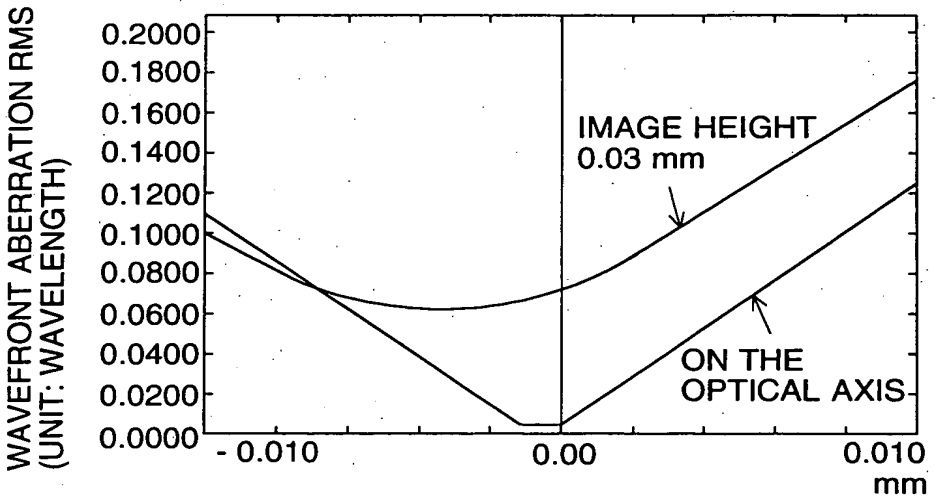

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 66

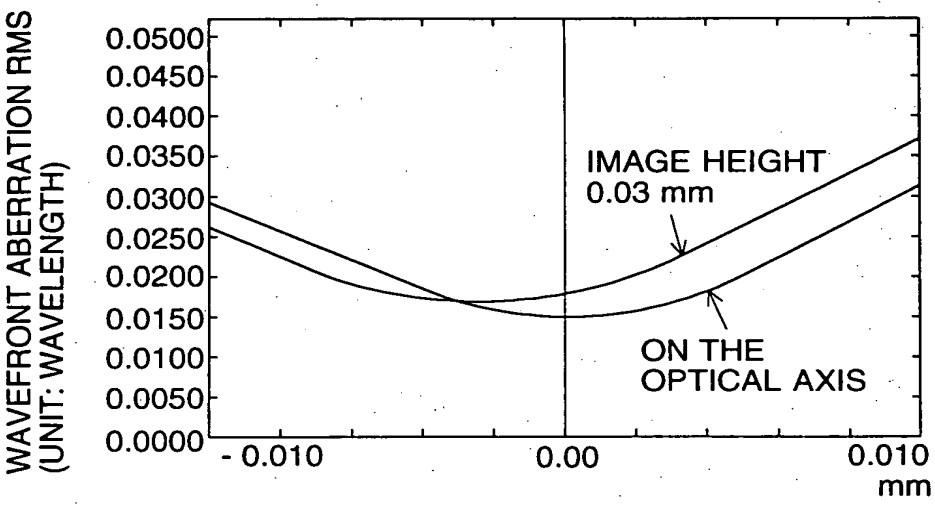

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.0500
0.0450
0.0400
0.0350
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
- 0.010
0.00
0.010
mm
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS

FIG. 67

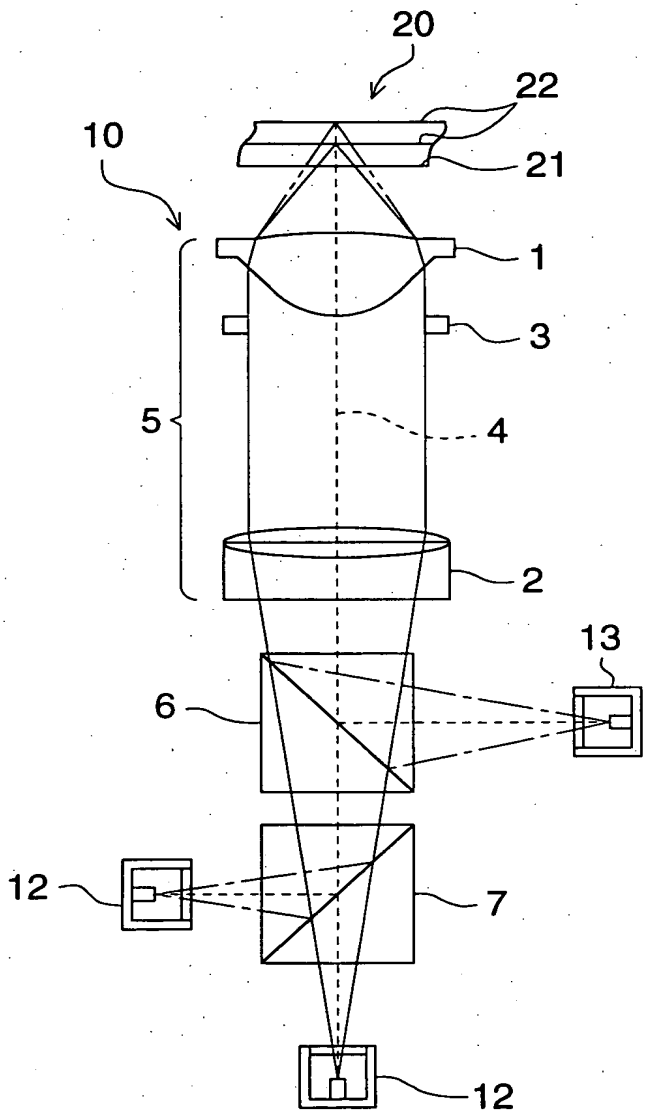


FIG. 68

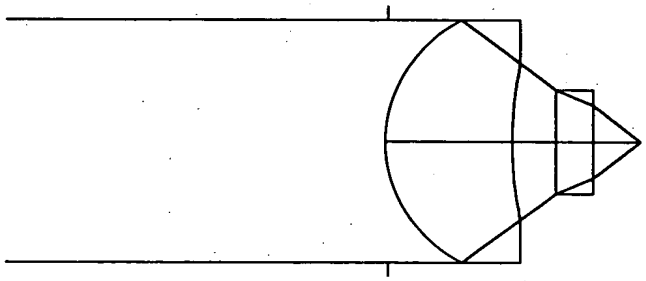


FIG. 69

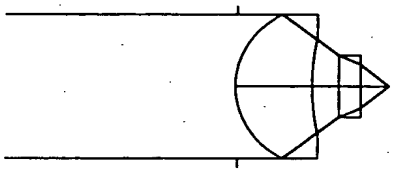


FIG. 70

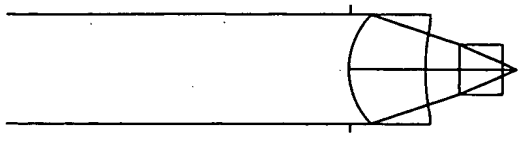


FIG. 71

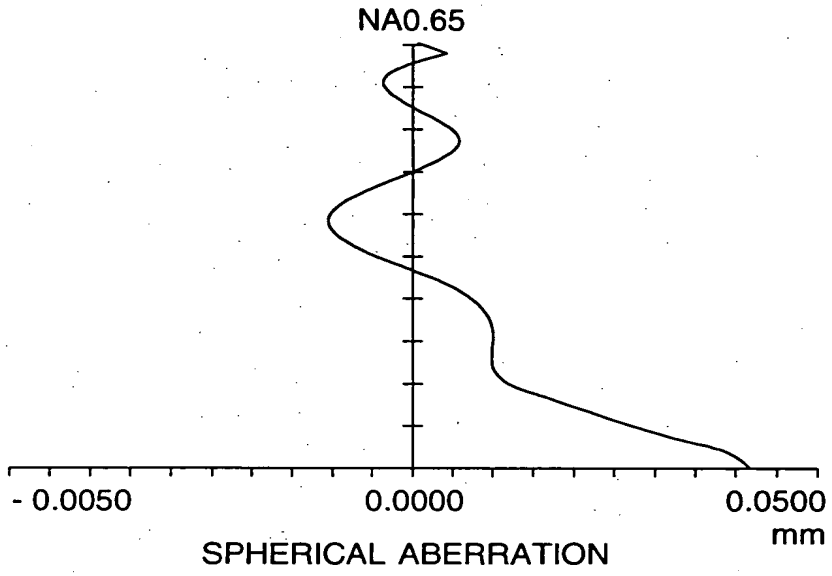

NA0.65
- 0.0050
0.0000
0.0500
mm
SPHERICAL ABERRATION

FIG. 72

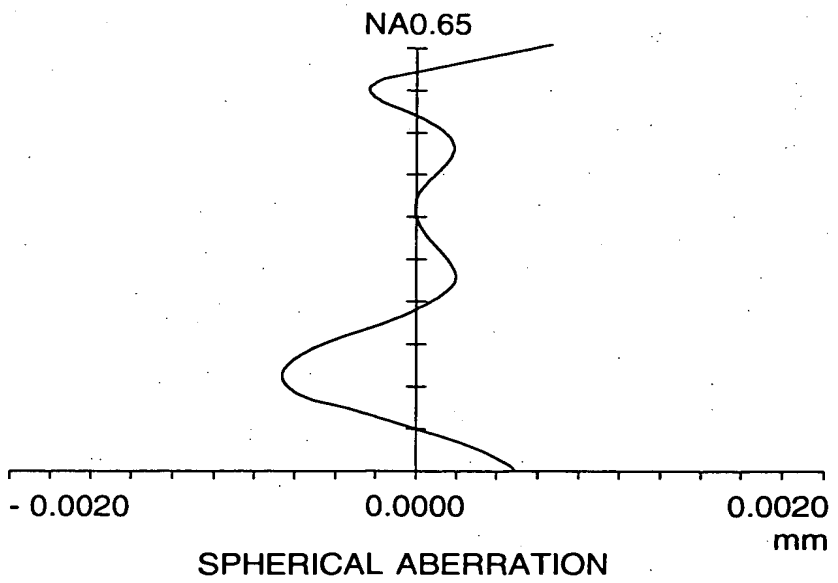

NA0.65
- 0.0020
0.0000
0.0020
mm
SPHERICAL ABERRATION

FIG. 73

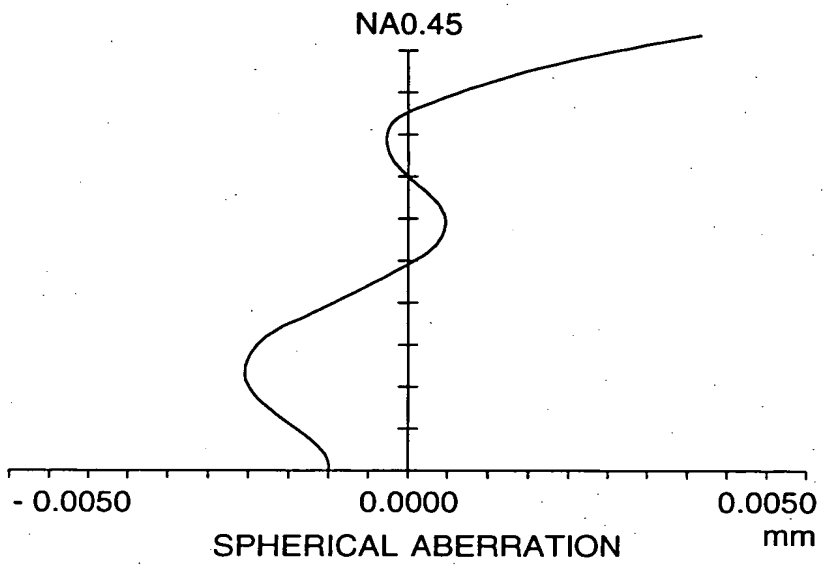

NA0.45
- 0.0050
0.0000
0.0050
mm
SPHERICAL ABERRATION

FIG. 74

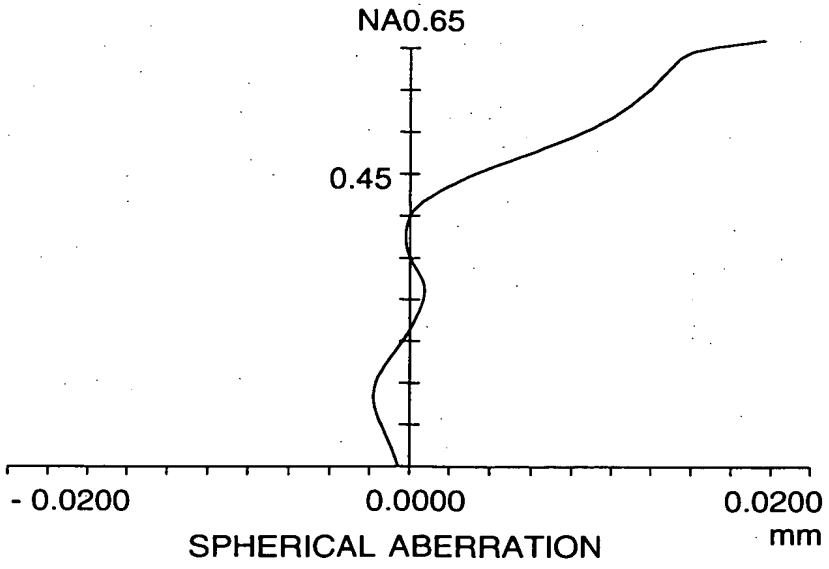

NA0.65
0.45
- 0.0200
0.0000
0.0200
mm
SPHERICAL ABERRATION

FIG. 75

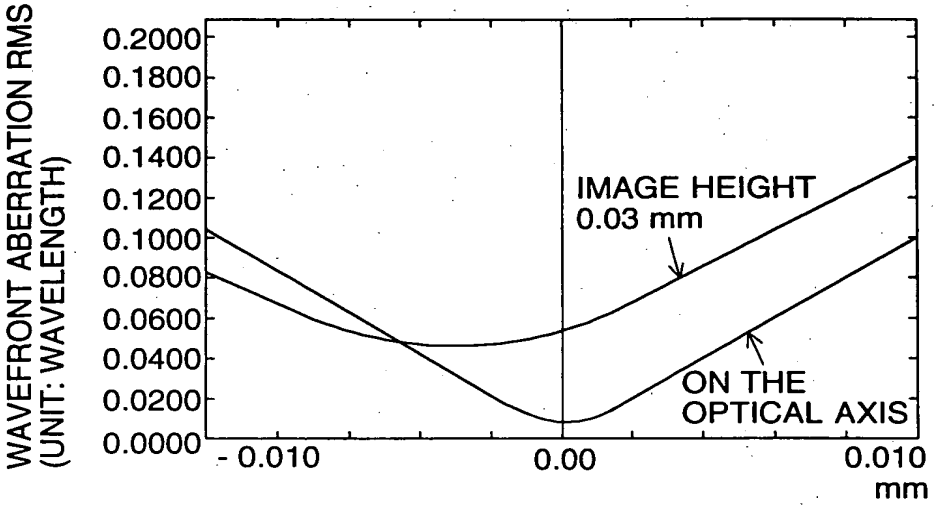

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 76

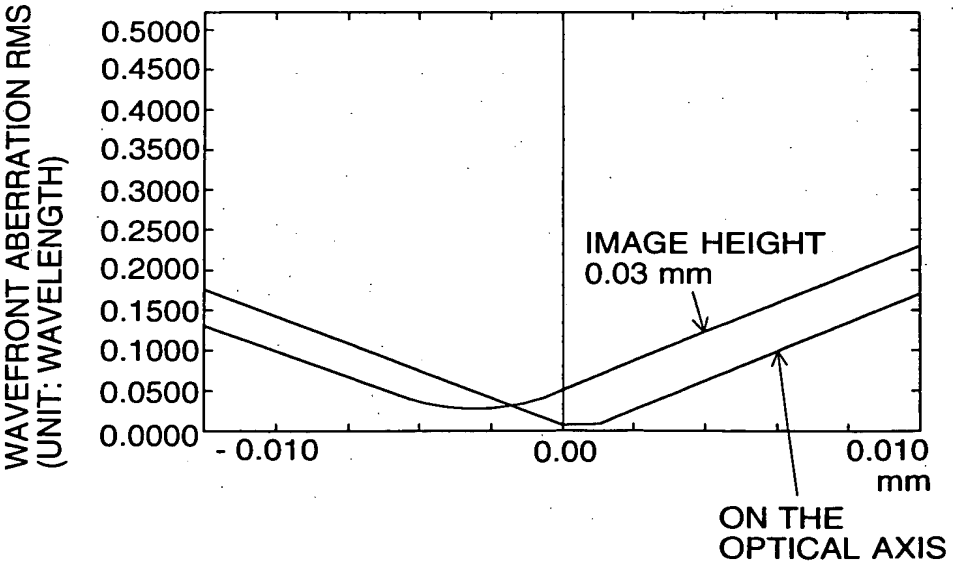

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.5000
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
IMAGE HEIGHT
0.03 mm
- 0.010
0.00
0.010
mm
ON THE
OPTICAL AXIS

FIG. 77

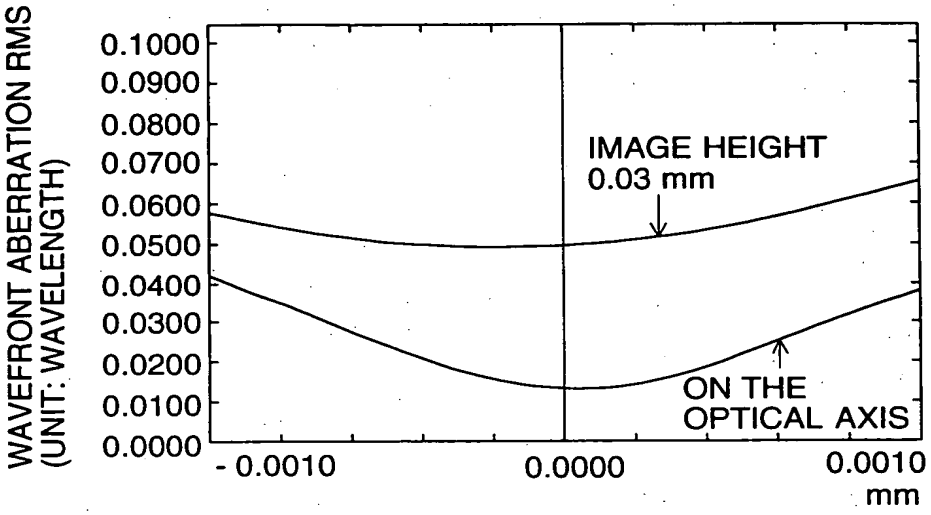


FIG. 78

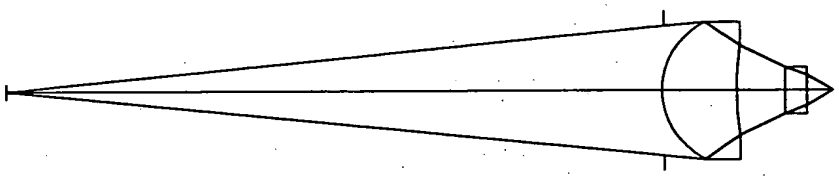


FIG. 79

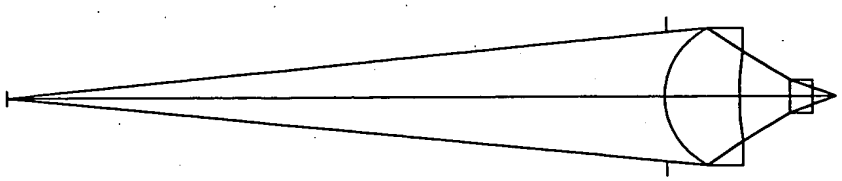


FIG. 80

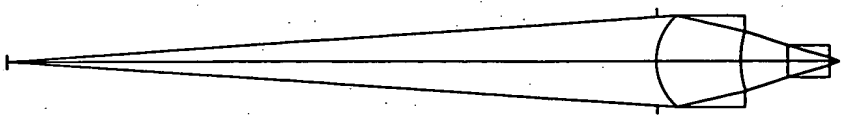


FIG. 81

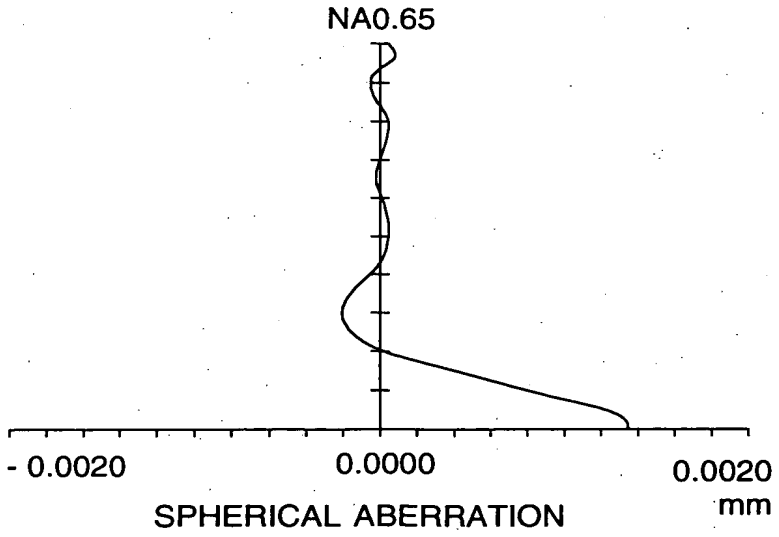


FIG. 82

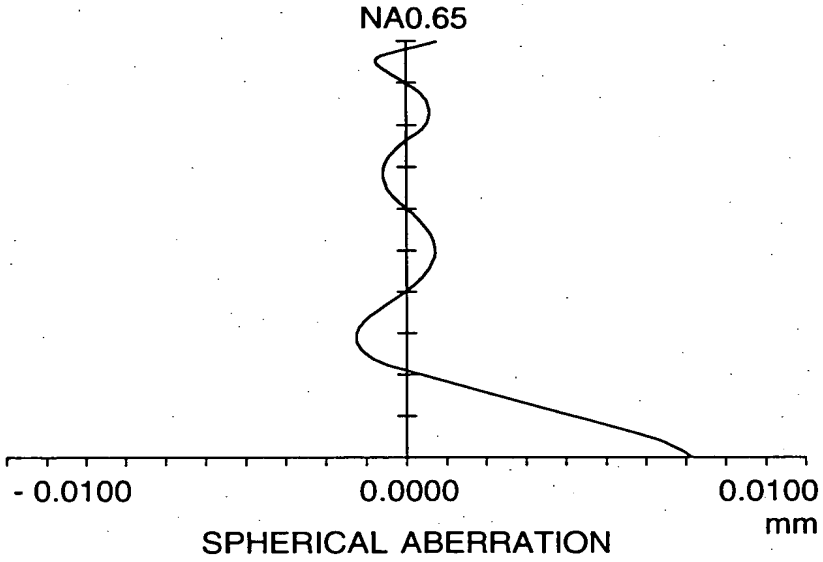

NA0.65
- 0.0100
0.0000
0.0100
mm
SPHERICAL ABERRATION

FIG. 83

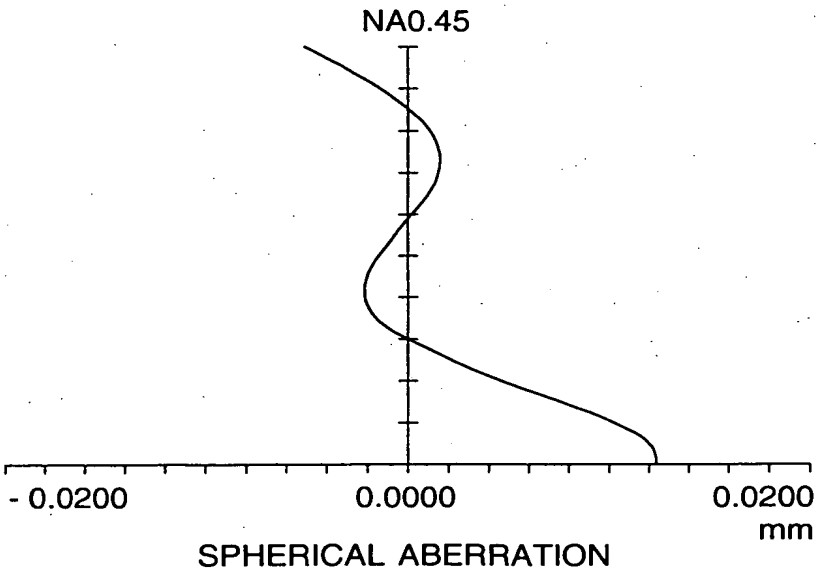

NA0.45
- 0.0200
0.0000
0.0200
mm
SPHERICAL ABERRATION

FIG. 84

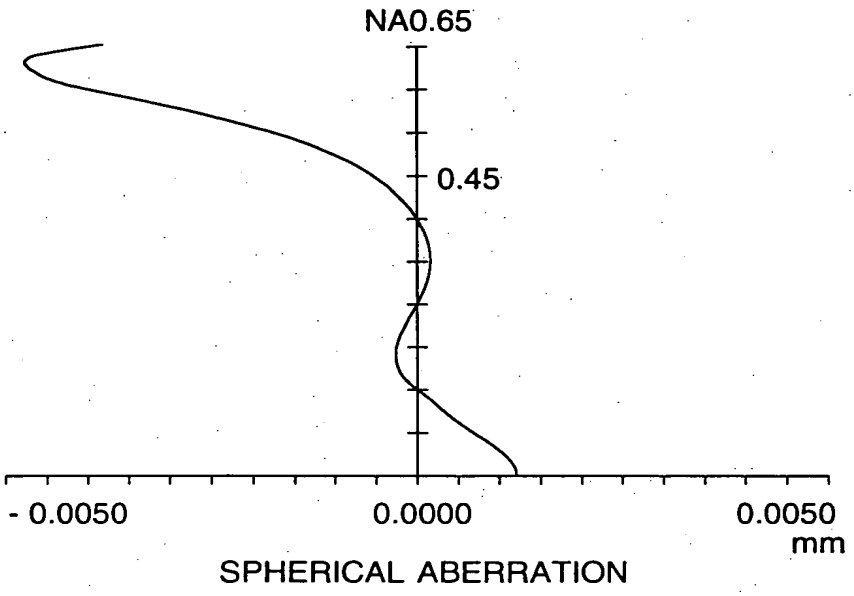

NA0.65
0.45
- 0.0050
0.0000
0.0050
mm
SPHERICAL ABERRATION

FIG. 85

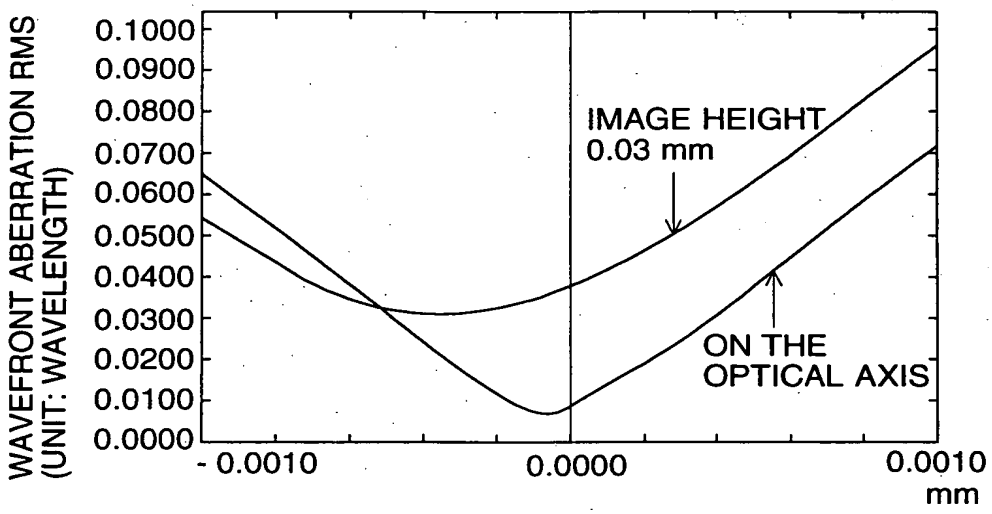

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.0010
0.0000
0.0010
mm

FIG. 86

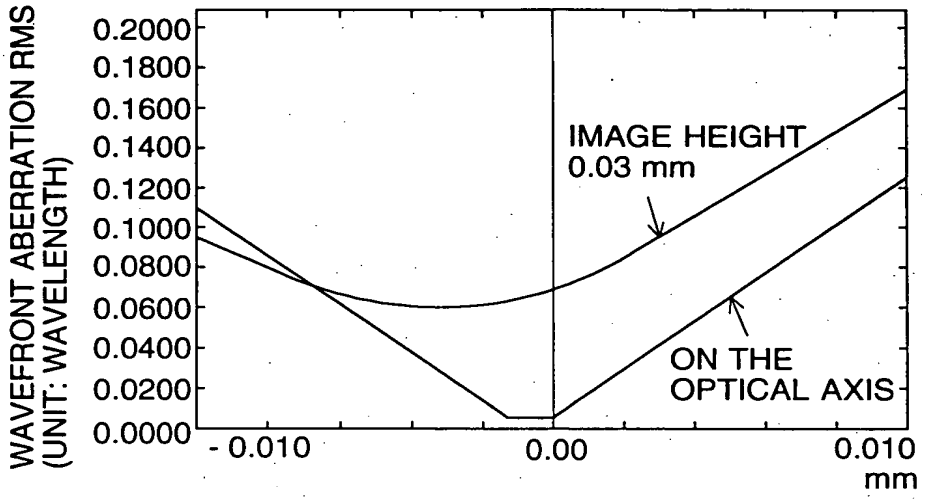

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 87

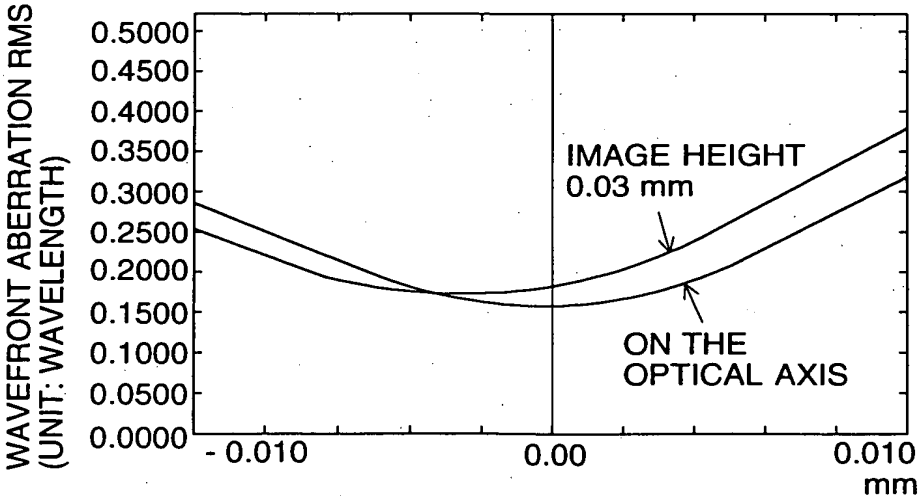

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.5000
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 88

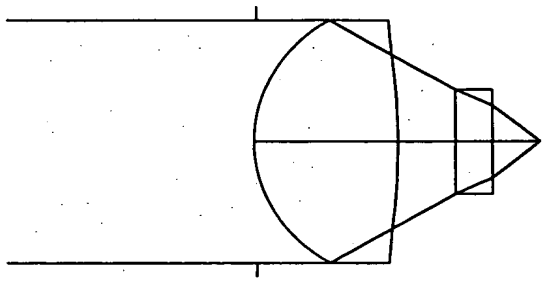


FIG. 89

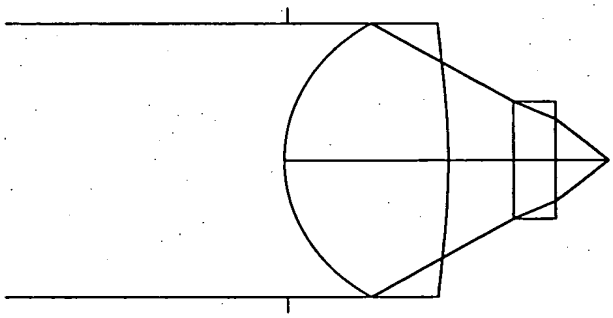


FIG. 90

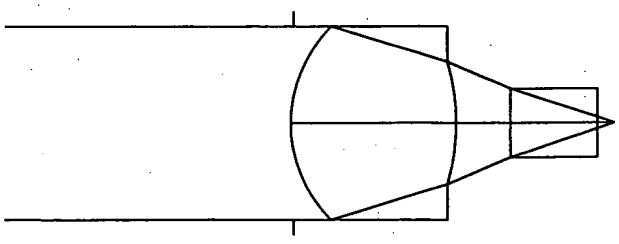


FIG. 91

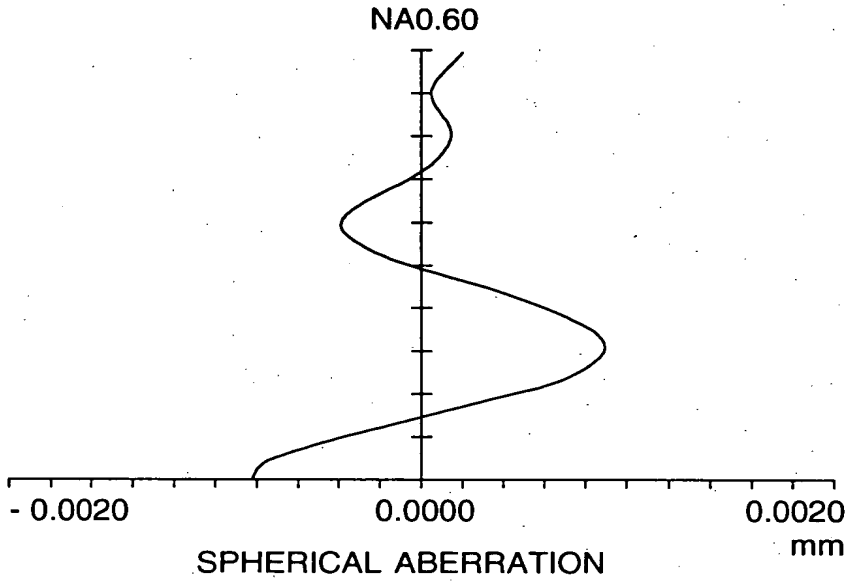

NA0.60
- 0.0020
0.0000
0.0020
mm
SPHERICAL ABERRATION

FIG. 92

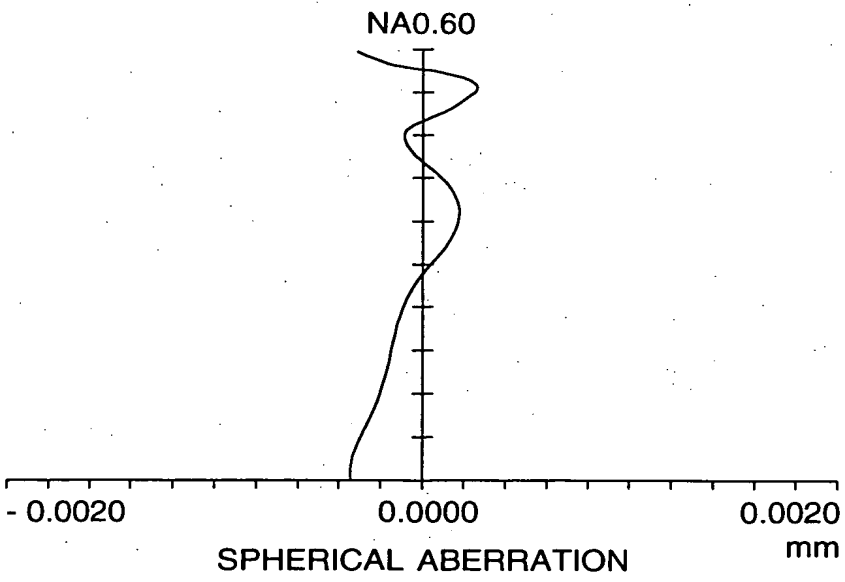

NA0.60
- 0.0020
0.0000
0.0020
mm
SPHERICAL ABERRATION

FIG. 93

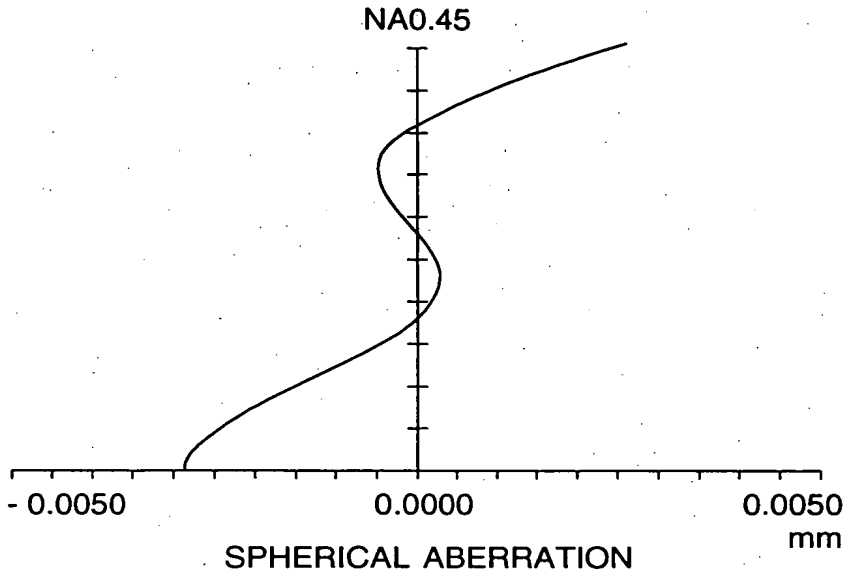

NA0.45
- 0.0050
0.0000
0.0050
mm
SPHERICAL ABERRATION

FIG. 94

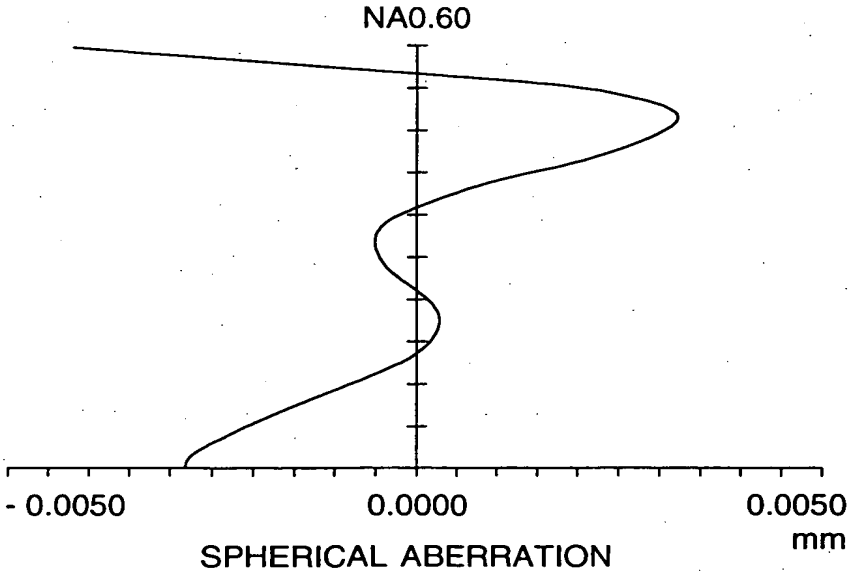

NA0.60
- 0.0050
0.0000
0.0050
mm
SPHERICAL ABERRATION

FIG. 95

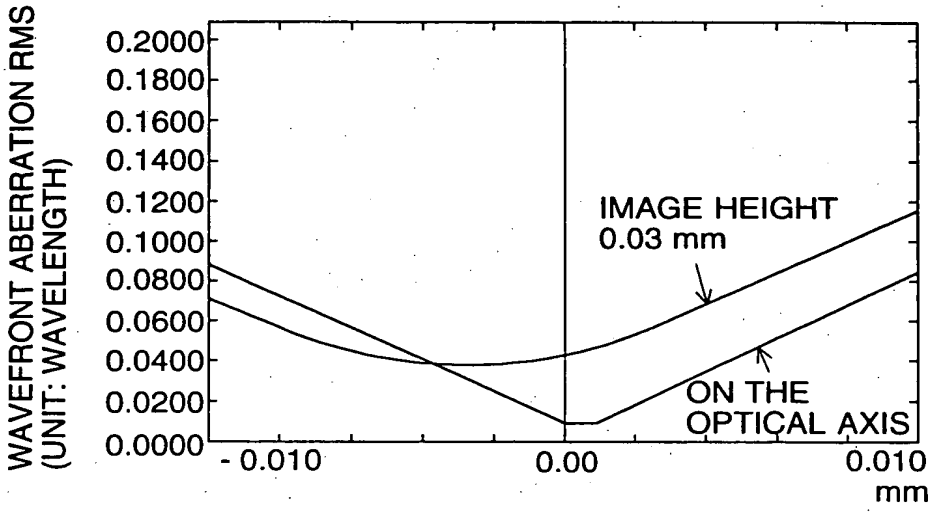

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 96

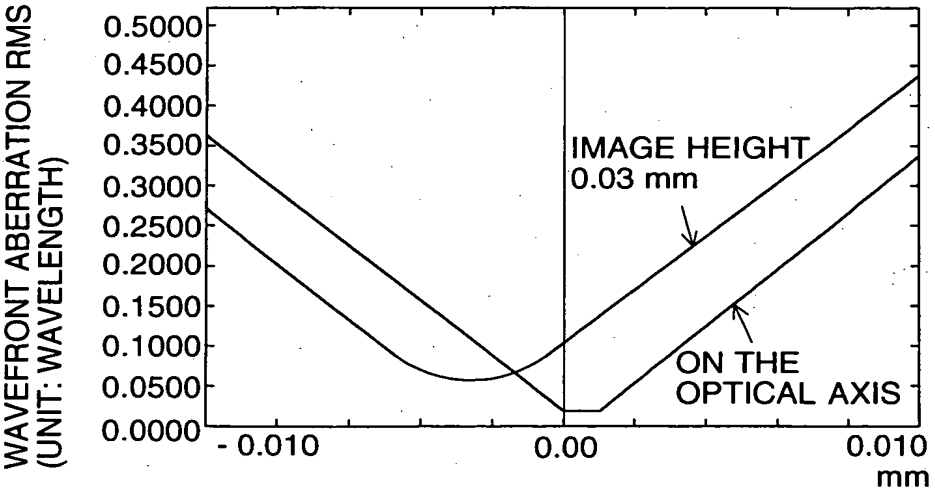

WAVEFRONT ABERRATION RMS
(UNIT: WAVELENGTH)
0.5000
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
IMAGE HEIGHT
0.03 mm
ON THE
OPTICAL AXIS
- 0.010
0.00
0.010
mm

FIG. 97

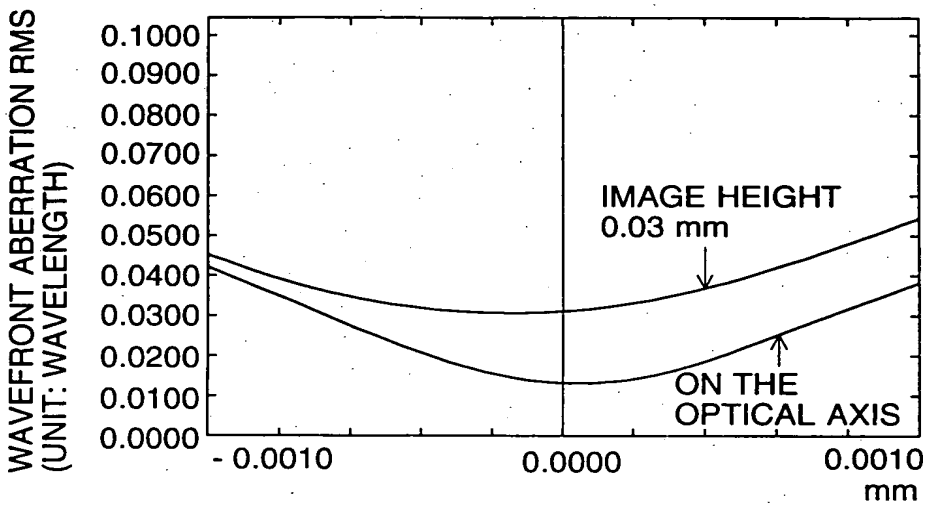
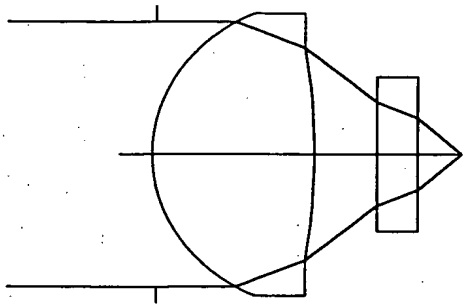


FIG. 98



CROSS SECTIONAL VIEW OF OBJECTIVE LENS AND ILLUSTRATION SHOWING OPTICAL PATH FOR WAVELENGTH λ =400nm

FIG. 99

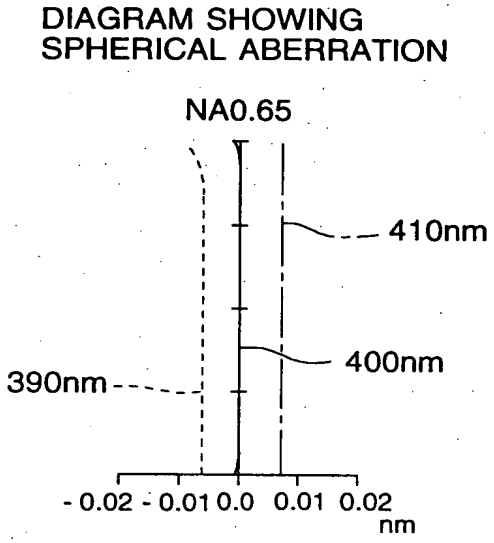


FIG. 100

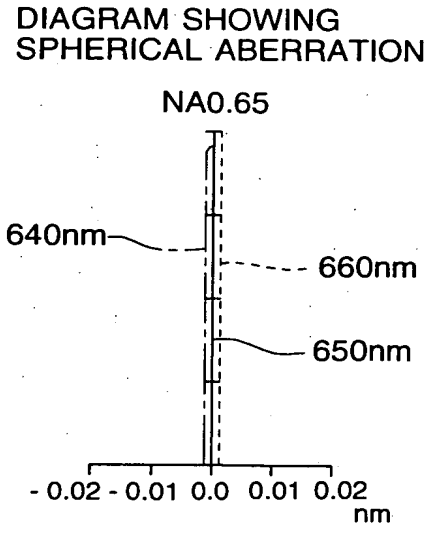


FIG. 101

DIAGRAM SHOWING
SPHERICAL ABERRATION

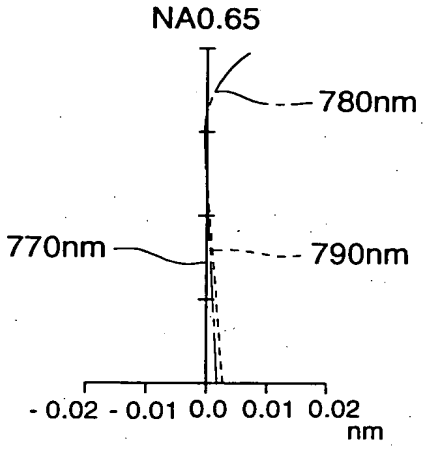


FIG. 102

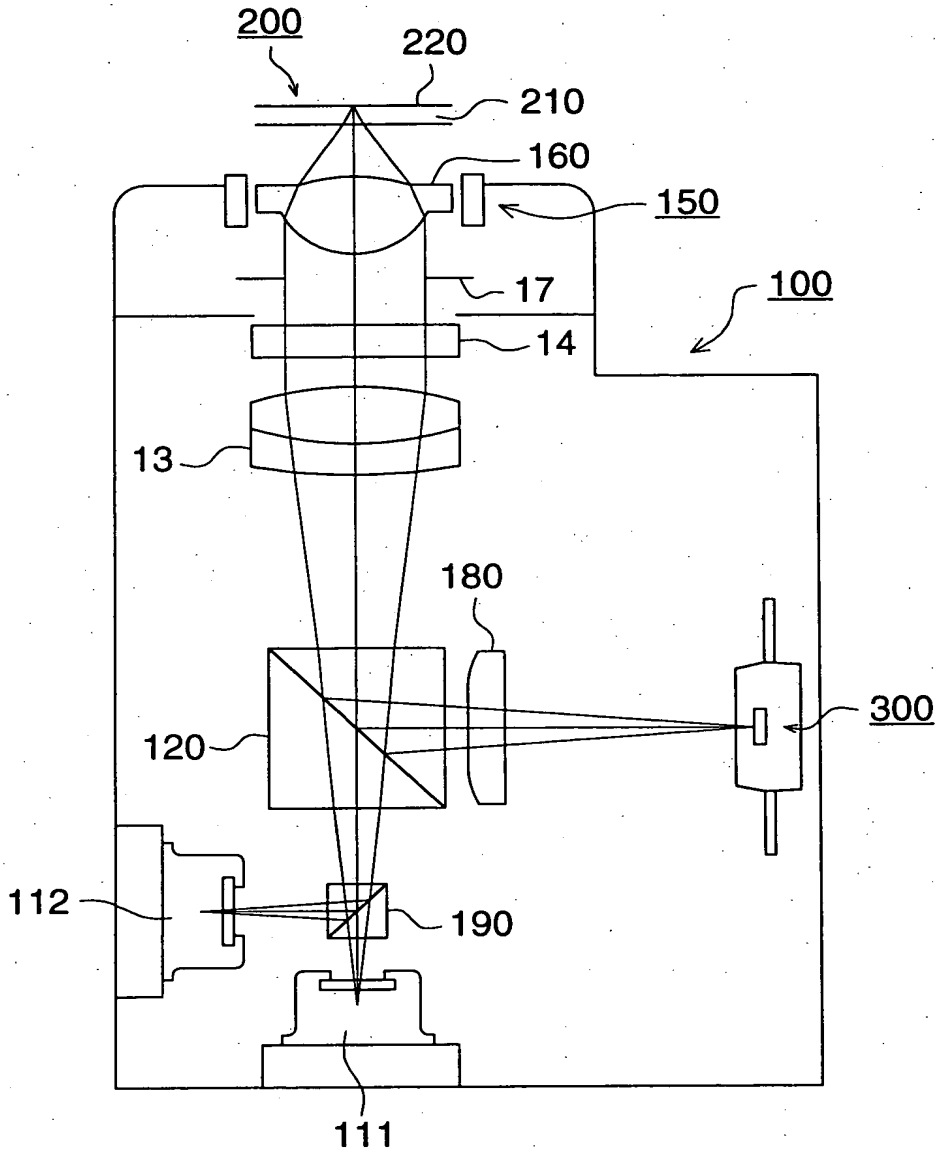


FIG. 103

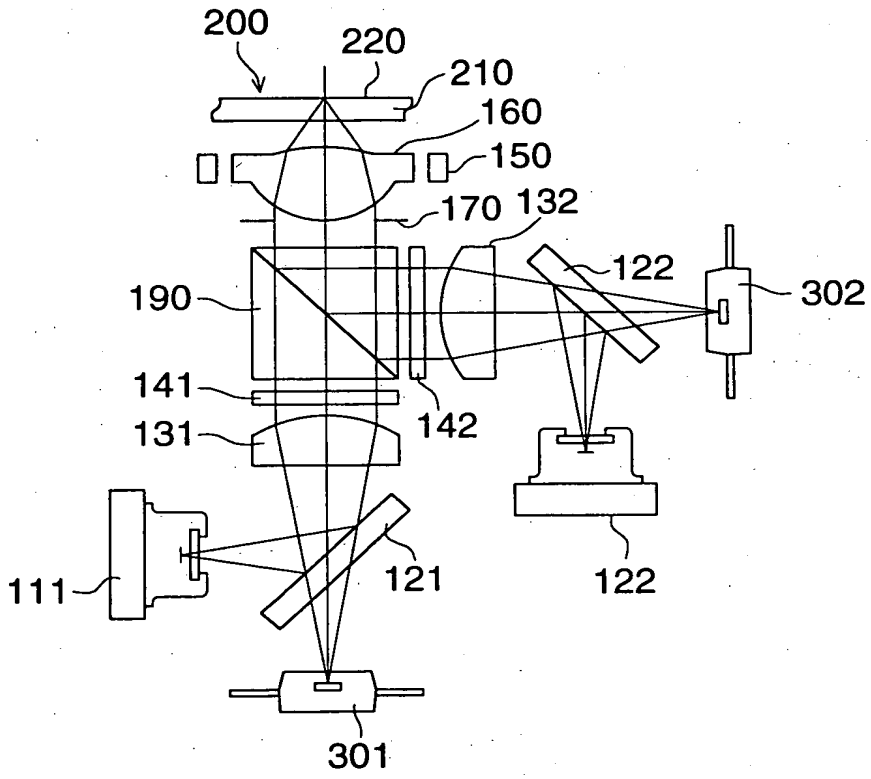

200
220
210
160
150
170
132
122
302
190
141
142
131
111
121
122
301

FIG. 104

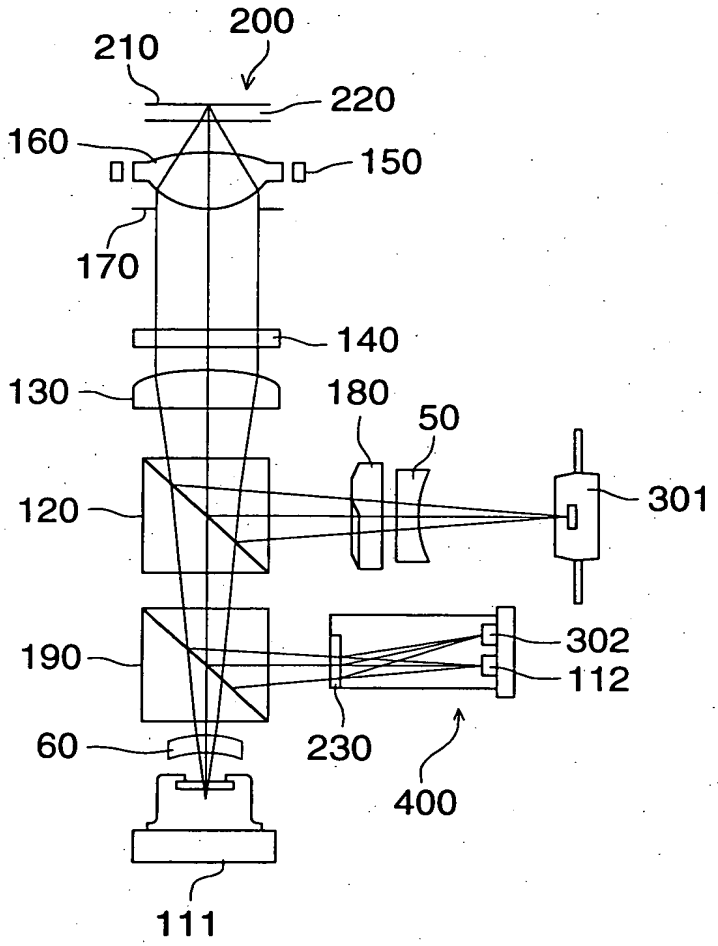

200
210
220
160
150
170
140
130
180
50
120
301
190
302
112
60
230
400
111

FIG. 105

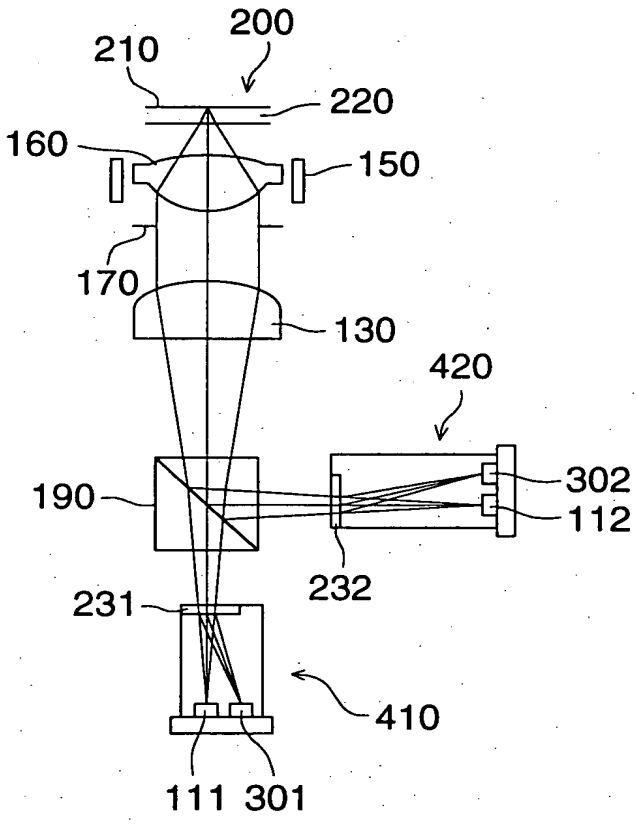


FIG. 106

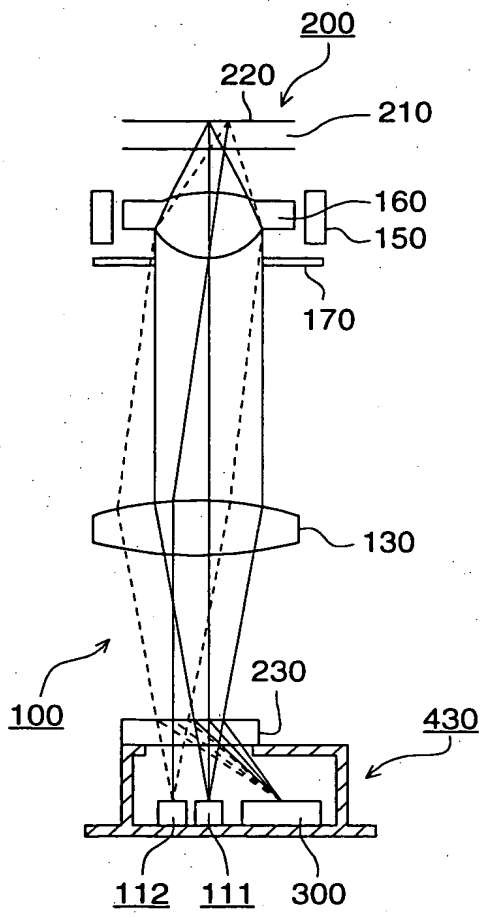


FIG. 107

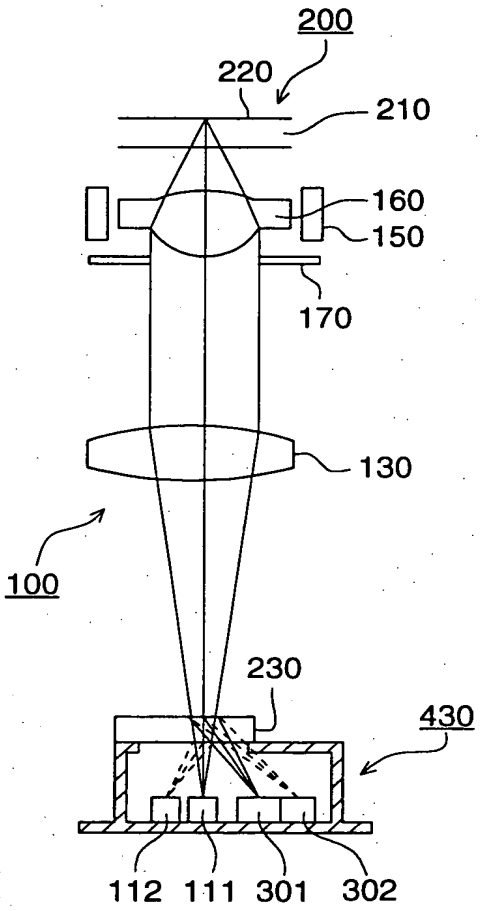


FIG. 108

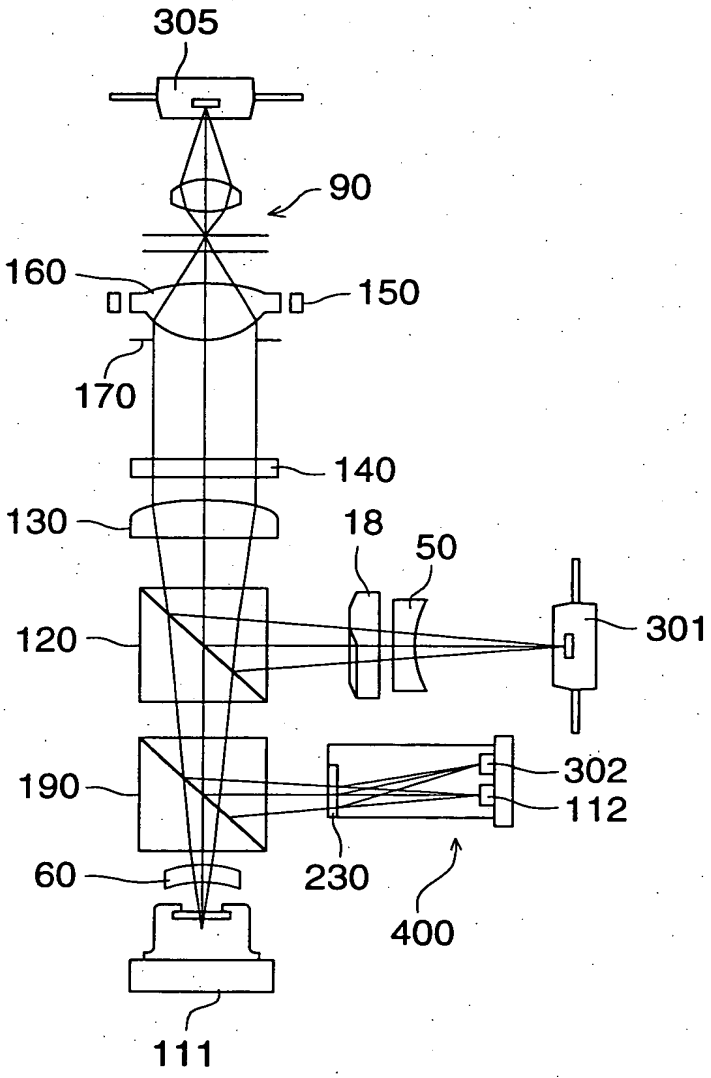

305
90
160
150
170
140
130
18
50
120
301
190
302
112
60
230
400
111

FIG. 109

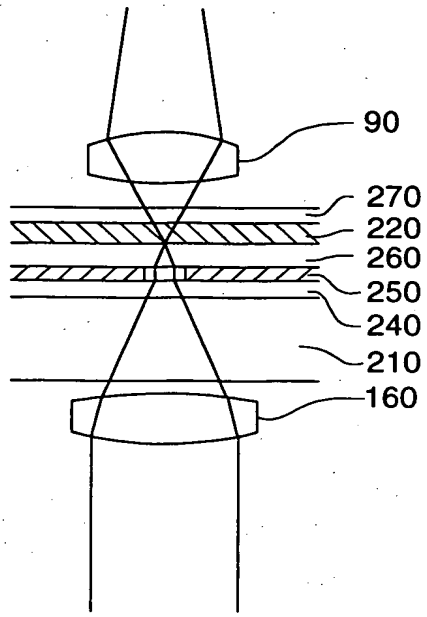


FIG. 110

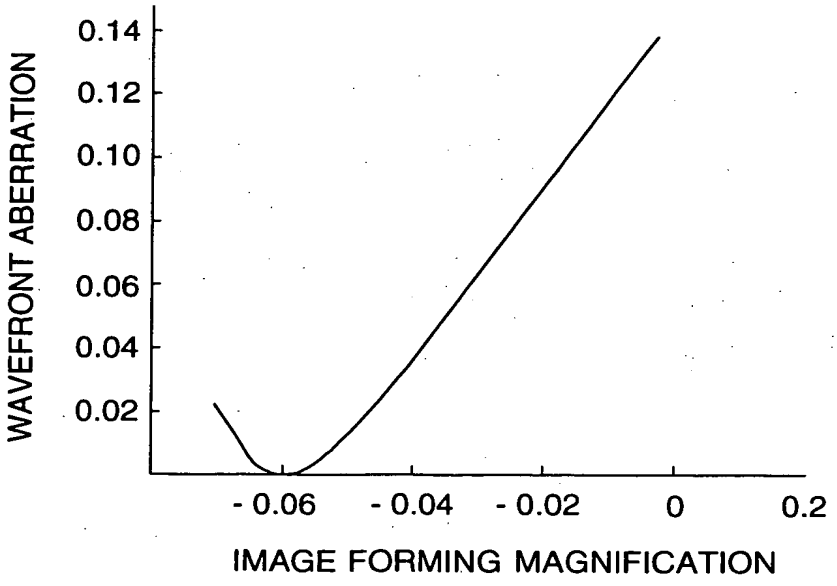
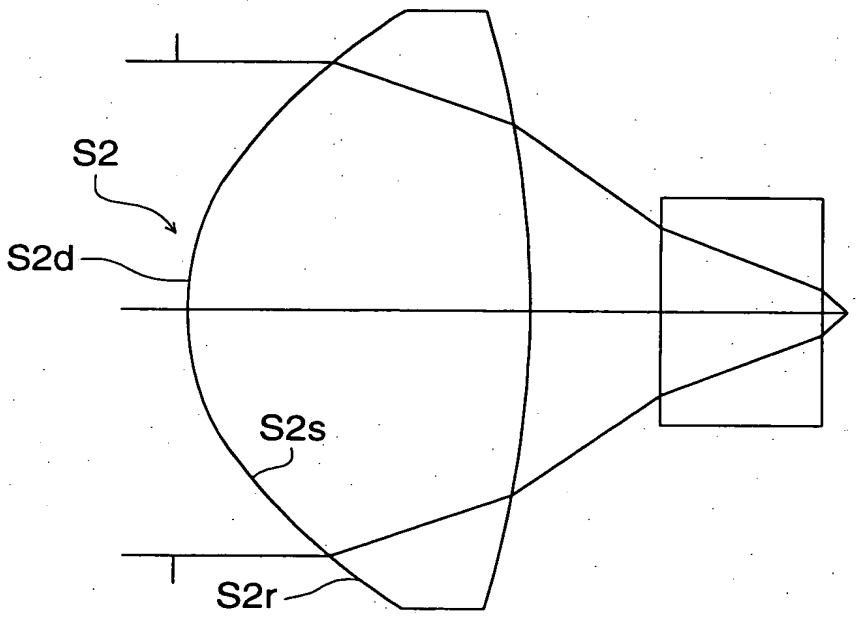


FIG. 111



<4235><4236><4237>
<4238><4239>
P68/81

FIG. 112 (a)

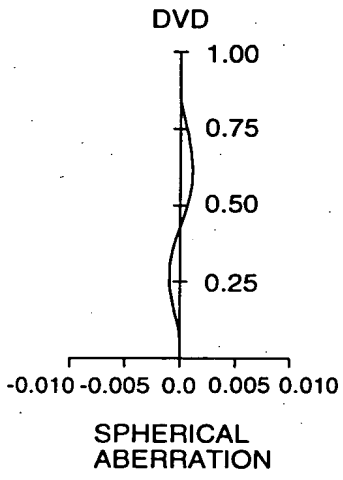


FIG. 112 (b)

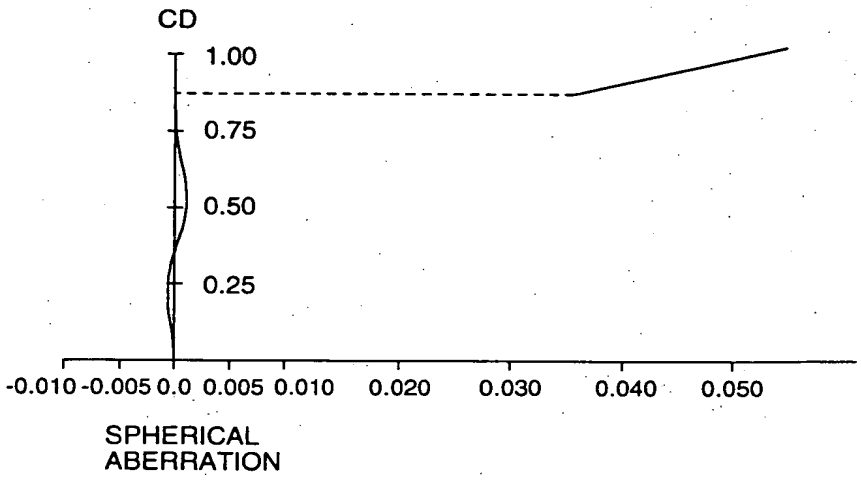


FIG. 113 (a)

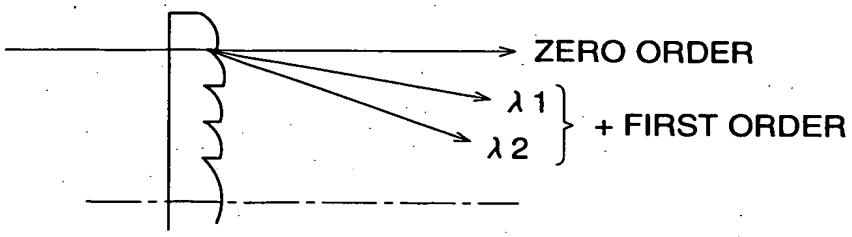


FIG. 113 (b)

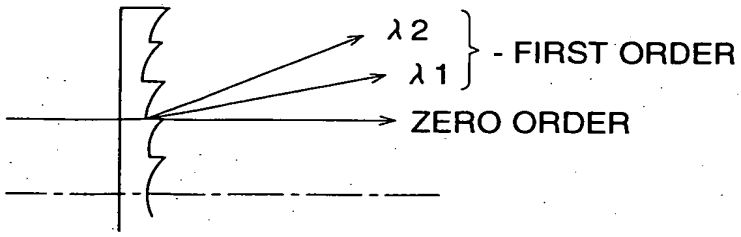


FIG. 114

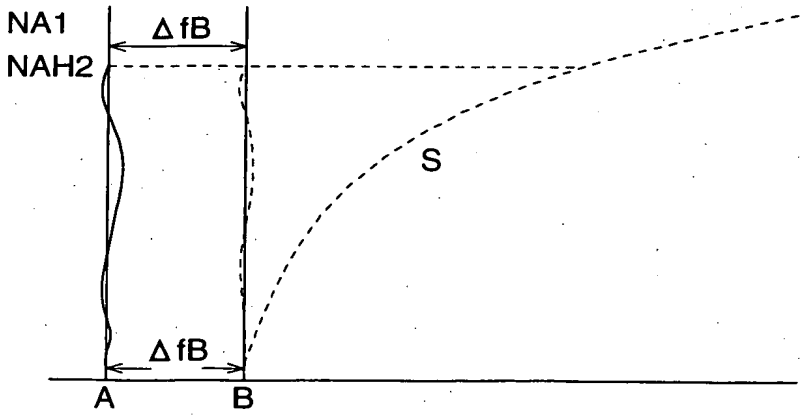


FIG. 115 (a)

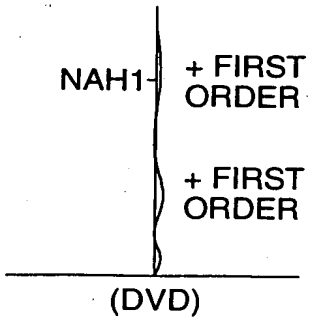


FIG. 115 (b)

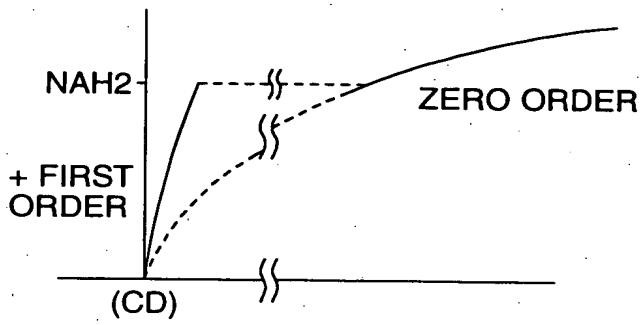


FIG. 116 (a)

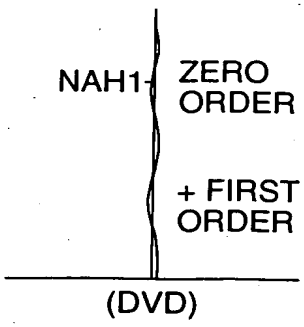


FIG. 116 (b)

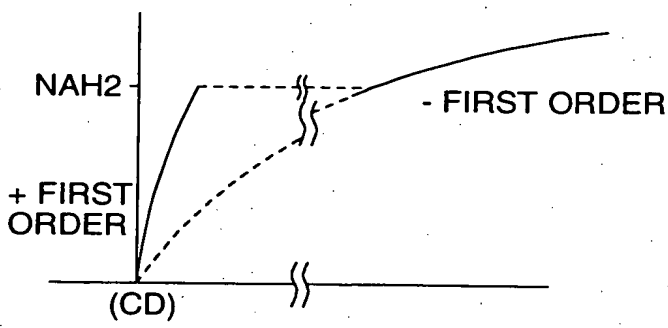


FIG. 117

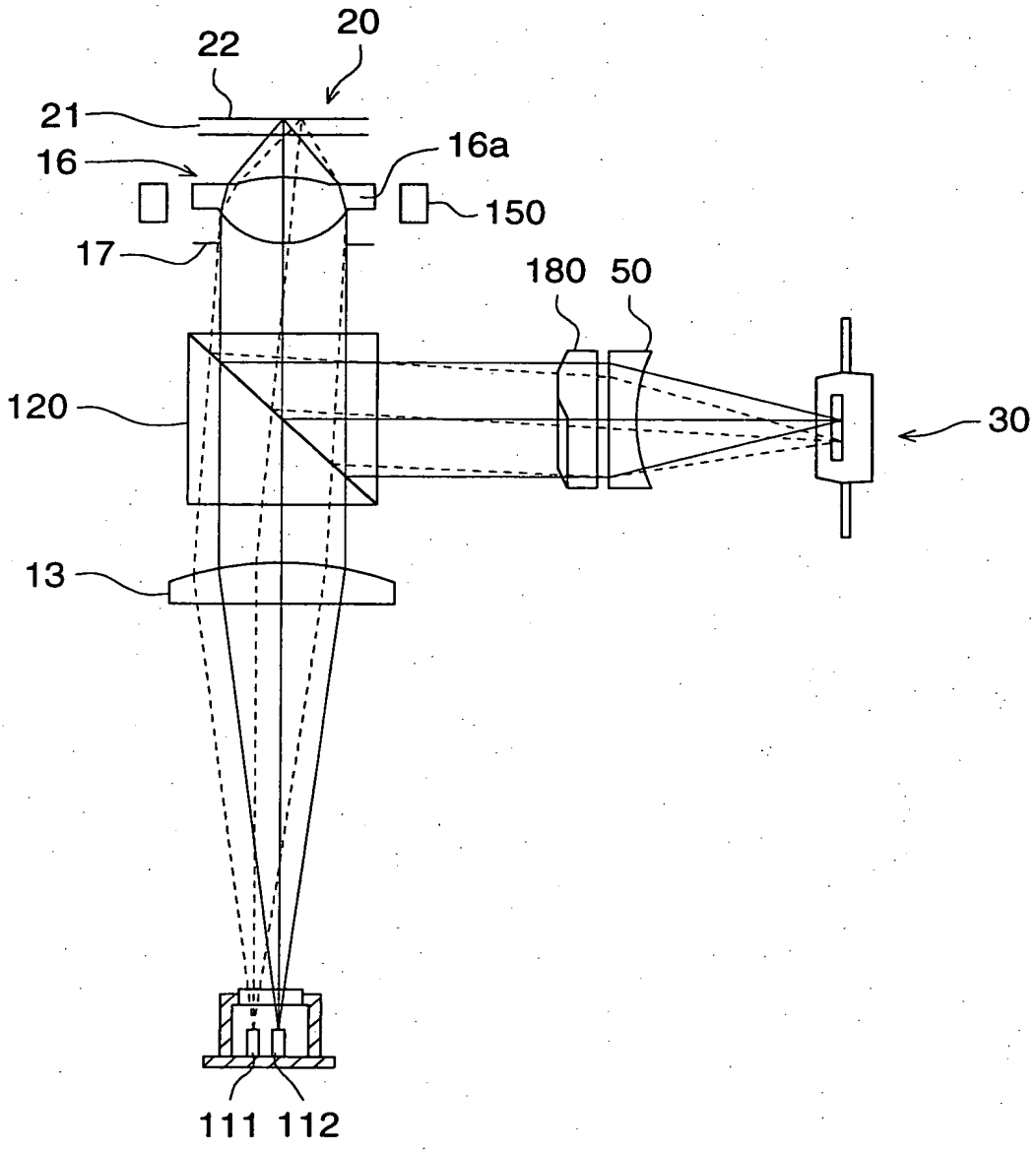


FIG. 118

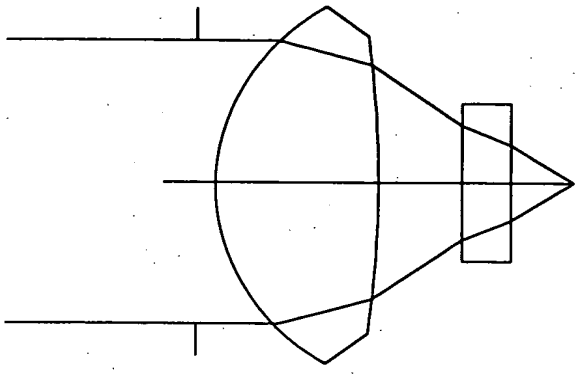


FIG. 119

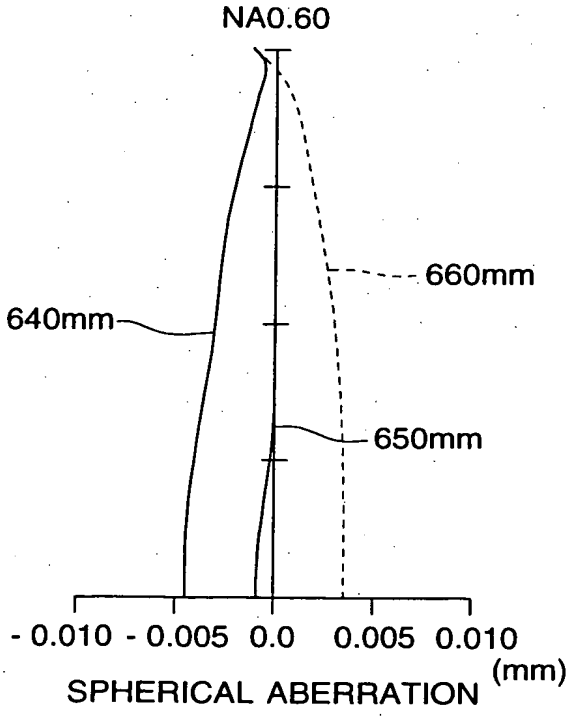


FIG. 120

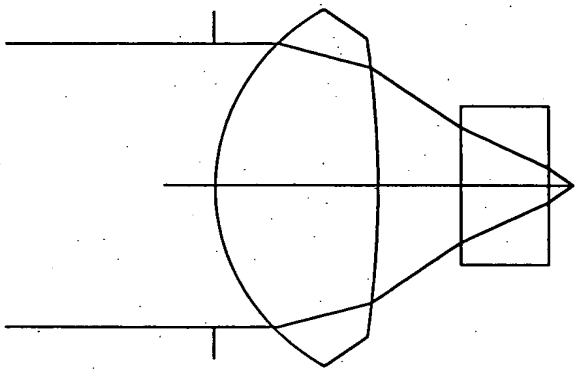


FIG. 121

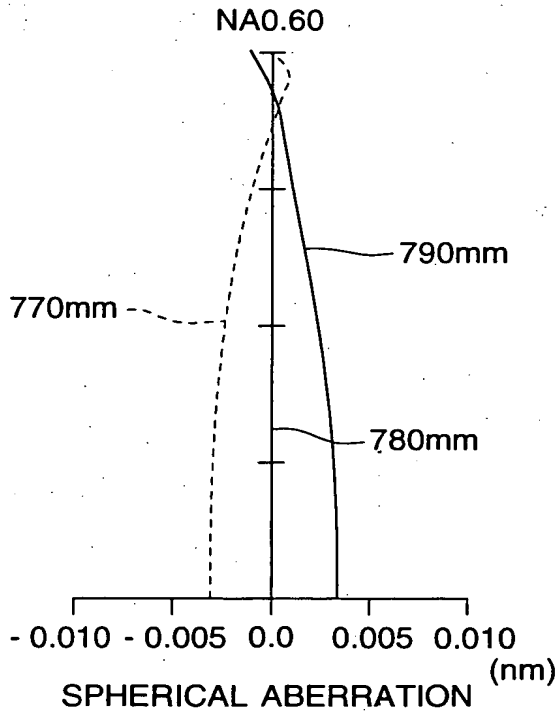


FIG. 122

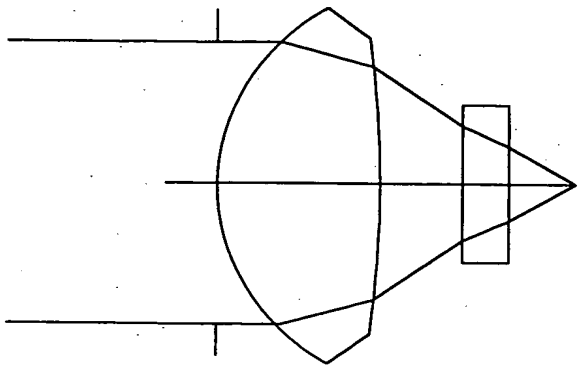


FIG. 123

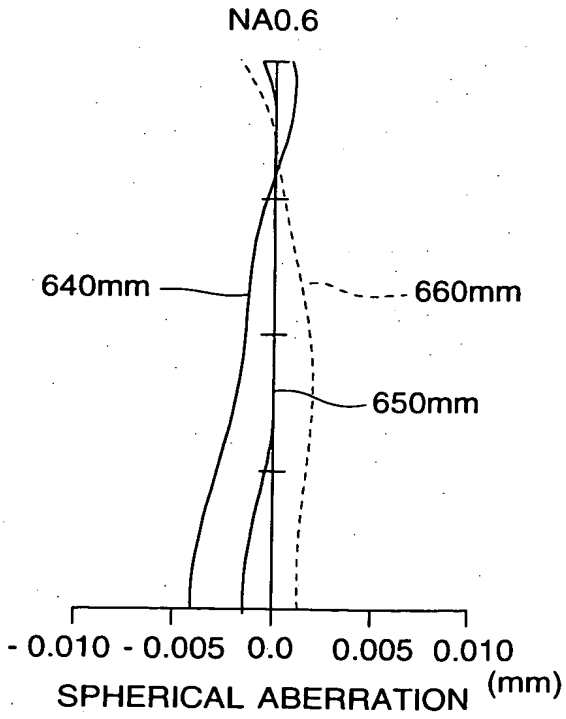


FIG. 124

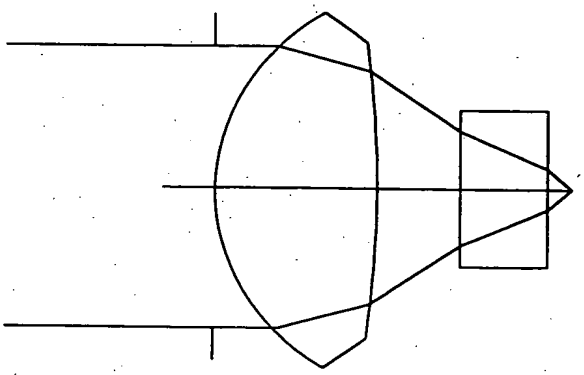


FIG. 125

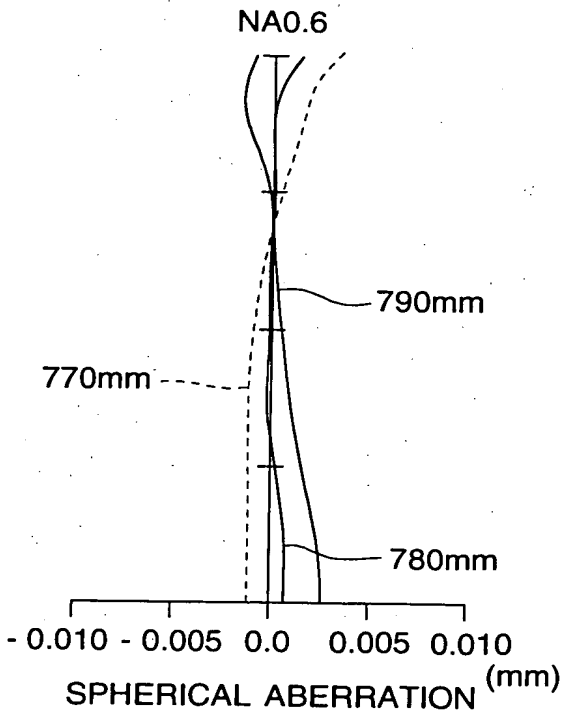


FIG. 126

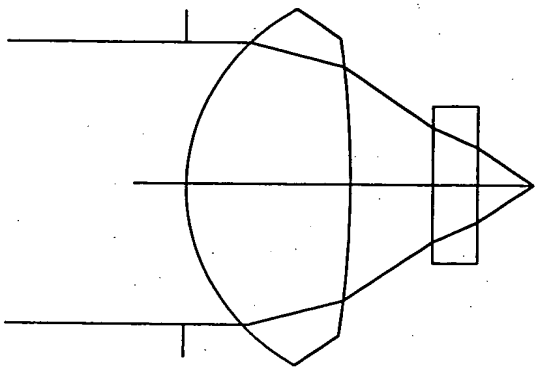


FIG. 127

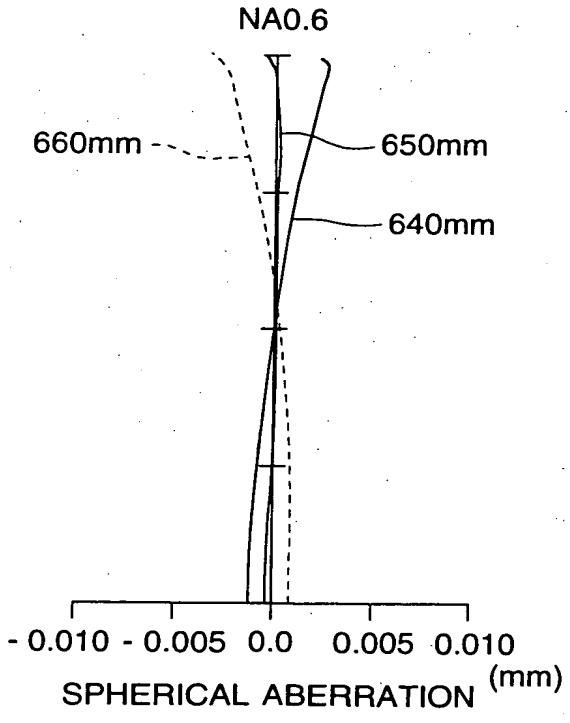


FIG. 128

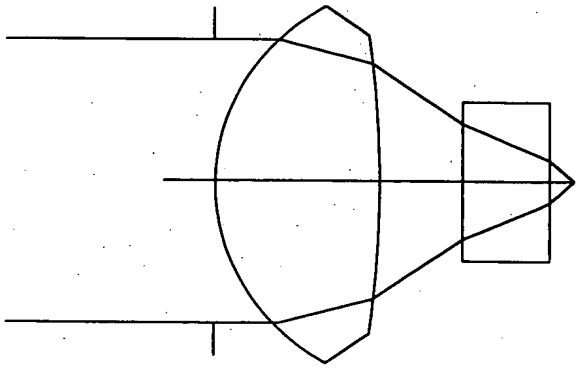


FIG. 129

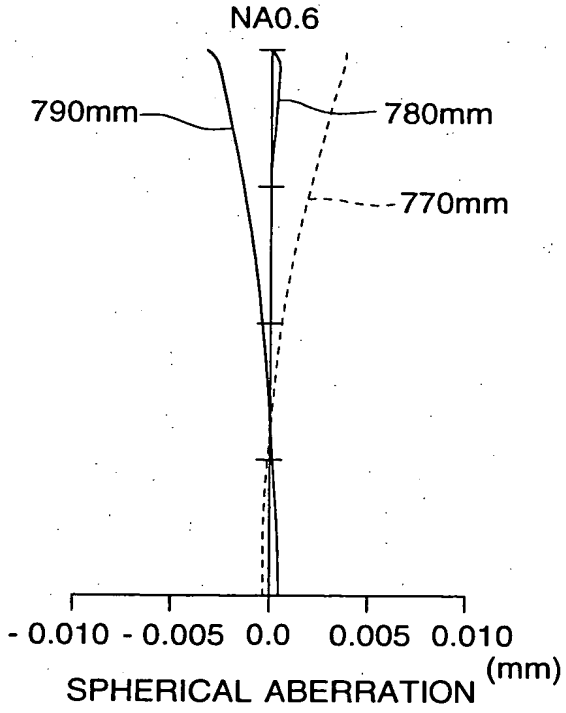


FIG. 130

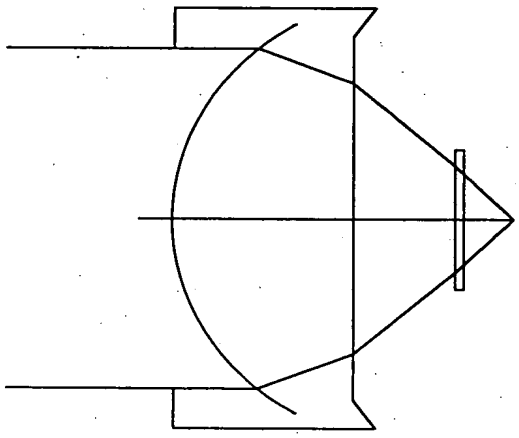


FIG. 131

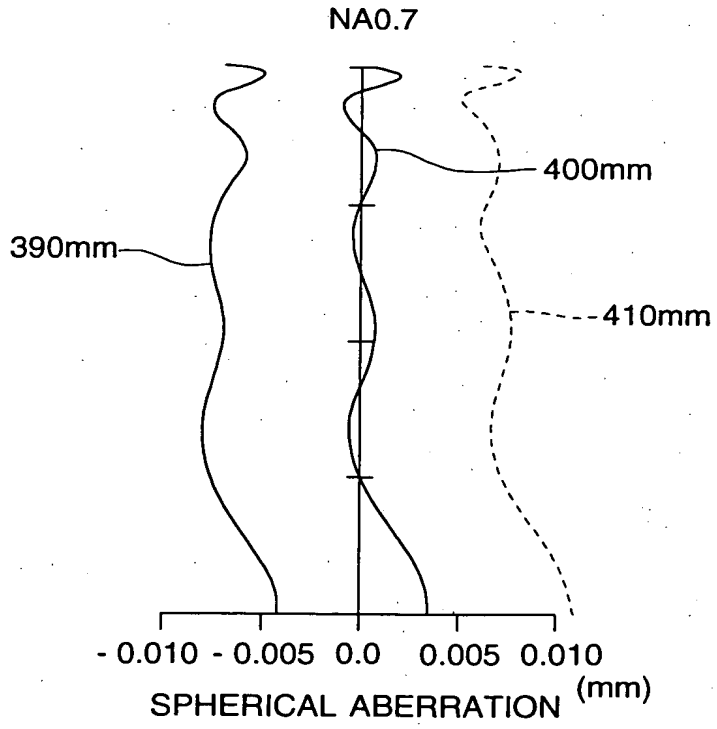


FIG. 132

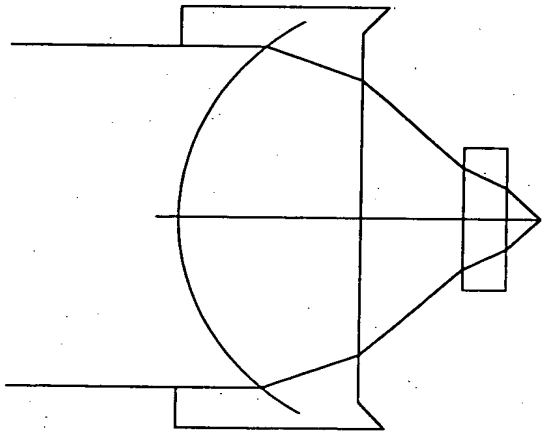
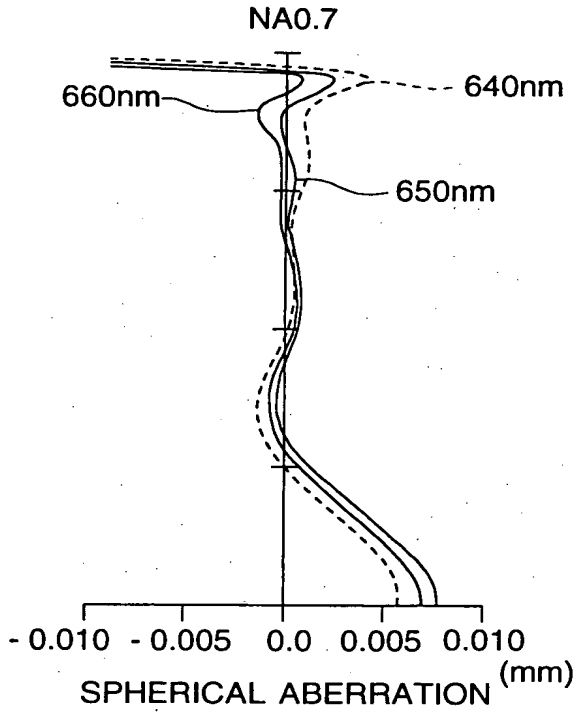


FIG. 133


NA0.7
660nm
640nm
650nm
- 0.010
- 0.005
0.0
0.005
0.010
(mm)
SPHERICAL ABERRATION

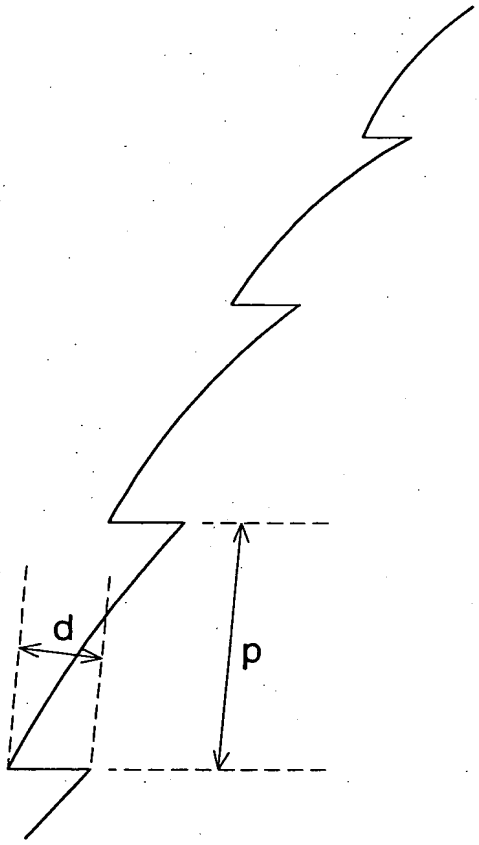



FIG. 134